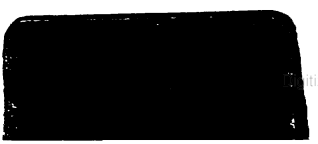

A NEW METHOD

WITH

PHYSIOLOGY

BY

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PREFACE.

EVERY skilled workman follows some plan in the execution of his task. No one is able to perform a piece of work with artistic neatness who does not have his method of operation well formulated, and who does not, in his mind's eye, see the beginning, the progress, and the completion of his labor.

So, every teacher who would be skilled in his profession, must look over the field which lies before him, and must arrange the material so systematically and logically correct that the subject may unfold itself to the learner in an intelligible, progressive, and interesting manner. With this in view, devices and expedients will suggest themselves, and that enthusiasm so necessary to mental development will be assured.

The following outlines may be used with much advantage in any class, and with any text book, yet the author hopes that they may be used rather as models by the aid of which the enterprising teacher may make outlines more especially adapted to his class, and to the text book in use. Or, better still, he may teach his class to do this.

The supplementary questions and answers are designed to stimulate research, and to bring out such points of interest, and such discussions, as may be of importance to the student, but which are not always found in the text books.

J. H. D.

WEST UNITY, O., *January, 1895.*

LESSON I.

MATERIAL SUBSTANCES.

TOPICAL OUTLINE.

I. Inorganic Bodies.

1. Mineral Kingdom.

1. Origin;
   1. Gravitation;
      1. Gravity; 2. Cohesion;
      3. Chemical Affinity.
   2. Crystalization.
2. Condition;
   1. Similarity of Parts;
   2. Absence of Organs;
3. Classification;
   1. Rocks; 2. Metals; 3. Water; 4. Air; etc.

II. Organic Bodies.

1. Vegetable Kingdom.

1. Origin;
   1. Composed of Cells;
   2. Formed from Air and Water.
2. Characteristics;
   1. Have a Period of Life;
   2. Dissimilarity of Parts;
   3. Grow Internally.
3. Classification;
   1. Phenogamia; 2. Cryptogamia.

2. Animal Kingdom.

1. Origin;
   1. Propagation; 2. Composed of Cells;
   3. Food;
      1. Organized Substances;
      2. Air and Water.
2. Endowments;
   1. Systems of Organs;
   2. Faculties of Special Sense.
3. Classification;
   1. Vertebrata; 2. Invertebrata.

SUPPLEMENTARY.

QUESTIONS.

1. Of what are air and water composed?
2. What difference exists in their formation?
3. What is meant by *chemical union? physical union?*
4. What are elements?
5. What are Phenogams? Cryptogams?
6. Do stones grow?
7. What are Vertebrates? Invertebrates?
8. What element in the air nourishes plants?
9. What constituent of the air sustains animal life?
10. What is an organ? A system? An apparatus?
11. What is chemical affinity?
12. What is a function?
13. Define Geology; Botany.
14. Define Physiology; Anatomy; Hygiene.
15. What opposing chemical changes are developed in the growth of plants and animals?
16. Do all animals have the power of moving about?
17. Have any plants the power of moving about?
18. How is it proved that plants take nearly all of their substance from the air?
19. Is it easy to distinguish between the lower forms of plants and animals?
20. What is Biology?
21. What is the chemical name for combustion? What does this term indicate?
22. What is chemistry?

ANSWERS.

1. Air is composed of two gases, oxygen and nitrogen. They are mixed together in the proportion of twenty parts of oxygen and seventy-seven parts of nitrogen.

Water is composed of oxygen and hydrogen in the proportion of one part of oxygen to two parts of hydrogen.

2. The elements of the air are not in chemical union and can be easily separated. The elements of water are in chemical union and can not be easily separated.

3. When elements are united chemically, they form a new substance and cannot be separated without destroying it. They can only be combined in certain proportions. When united physically the identity of the elements is not changed, and no new substance is really formed. They can be mixed in any proportions.

4. An element is one of the essential or principal parts of which a substance is composed. The term as used here has reference to atomic composition; as, for instance, when two atoms of hydrogen unite with one of oxygen the product is water.

5. Plants which bear flowers are called Phenogamous; those which bear no flowers are called Cryptogams.

6. Stones which are imbedded in the ground are supposed to increase in size by the petrifaction of the particles of earth in contact with them. Stones which are exposed are gradually crumbled by the elements.

7. The animal kingdom is divided into two divisions; those which have a back-bone—Vertebrates; and those which have no back-bone—Invertebrates.

8. The Carbon. See question 15.

9. The Oxygen. See question 15.

10. An organ is a certain part of the body which performs a particular work. A number of organs concerned in the performance of duties related in character is called a system. An apparatus is a collection of related systems.

11. Chemical affinity is that power which holds the different elements together, and causes chemical union. If chemical affinity should cease the human body (as well as all organic substances) would dissolve into three invisible gases, and a substance like charcoal.

12. The particular use of an organ system, or apparatus, is called its function.

13. Geology is the science which treats of the mineral constitution and structure of the earth. Botany treats of the structure, growth, functions and classification of plants.

14. Physiology treats of the organs and their functions. Anatomy treats of the structure of the body. Hygiene treats of the laws of health.

15. Plants, in their respiration, decompose the carbonic acid gas in the air, appropriating the carbon (which forms the greater part of their substance) and setting free the oxygen. In the respiration of animals (this term includes human beings) the oxygen of the air is combined with the carbon of the decomposing parts of the body and carbonic acid gas is formed. Thus, we see how plant and animal life are interdependent.

16. Some of the lower animals do not have the power of locomotion. The sponges, the "stone lily," and the lamp shell are specimens of animals that do not have these powers. In appearance they are much more like plants than animals.

17. A plant which grows in the Santee river floats about, attaching itself to objects, and freeing itself, by what seems like the plant's will. The Venus fly-trap, and the sun dew move their leaves on being touched.

18. Take a box and fill it with a certain weight of dry earth. Moisten it and plant a seed of some large, rapidly growing plant. When the plant has attained a considerable size, pull it up, dry, and weigh it; then weigh the earth (dried) again, and it will be found that the weight of the plant far exceeds the loss of weight of the earth. Whence did this extra material come? It is nearly all carbon, and it came from the air. It could not have come from the water because the water contains no carbon.

19. Plants and animals of the lower forms are very difficult to distinguish. The sponges were for ages classified as plants, but they are now believed to be animals.

20. Biology is the science of life.

21. Combustion is called *oxidation.* Fire is produced by the clashing of the atoms of oxygen with some other element. Without oxygen no combustion is possible. Oxygen burning in hydrogen gas forms water; burning in carbon gas it forms carbonic acid.

22. Chemistry is the science which treats of the composition of substances, and the changes in their composition.

LESSON II.

THE HUMAN BODY.

TOPICAL OUTLINE.

1. Cells.

1. Composition and Parts;
   1. Protoplasm; 2. Nucleus; 3. Nucleolus; 4. Granules; 5. Enveloping Membrane.
2. Phenomena;
   1. Motion; 2. Growth; 3. Division.
3. Form and Size.

2. Tissues.

1. Formation;
   1. Cells Arranged in Layers.
2. Kinds;
   1. Connective;
      1. Fibrous; 2. Areolar; 3. Cartilaginous.
   2. Adipose; 3. Sclerous; 4. Muscular; 5. Tubular; 6. Nervous.

3. Membranes.

1. Fibrous; 2. Serous; 3. Synovial; 4. Mucous.

4. Systems of Organs.

1. Motary System;
   1. Osseous; 2. Muscular;
2. Nutritive System;
   1. Digestive; 2. Circulatory; 3. Respiratory.
      1. Accessory:—1. Absorptive; 2. Secretory; 3. Excretory.
3. Sensory System;
   1. Nervous.
      1. Accessory:—1. Special Senses.

5. Parts.

1. Head; 2. Trunk; 3. Extremities.

SUPPLEMENTARY.

QUESTIONS.

1. Can you describe the Amoeba?
2. What is segmentation? Gemmation?
3. What is the size of a cell?
4. Into what classes are cells divided?
5. Does the Amoeba have a heart?
6. Define the term *growth* as applied to the human body?
7. What is a *secondary*, or *accessory*, function?
8. What is meant by the term *life* and *death* as applied to the cell?
9. What other name is given to the areolar tissue?
10. What are basement membranes?
11. What is epithelium?
12. Into what three classes are cartilaginous tissues divided?
13. What are the two kinds of muscular tissue?
14. What are lamellæ?
15. What fluids are secreted by the membranes?
16. What is meant by storage tissue?
17. What is a "weeping sinew?"
18. Define Histology.

ANSWERS.

1. The Amoeba is a microscopic animal consisting of a single cell. It is the simplest form of animate existence.

2. The simple cell becomes constricted at its center, producing a shape like the figure eight; and, finally dividing, forms two perfect cells. This is called segmentation. Sometimes a little projection, like a bud, is thrust out from the cell, which is set free. This is gemmation.

3. A cell is about $\frac{1}{2000}$ of an inch in diameter. The size is variable.

4. Into three classes: *1st*—Floating in liquids; *2d*—Imbedded in solids; *3d*—On free surfaces.

5. There is a little "pulsating vacuole" in the center of the animal which is thought to be the origin of the

movements within. This, no doubt, performs the same functions for this tiny being as the heart for the higher animals.

6. The growth of the body is due to the multiplication of cells. Growth does not in any way denote a change in the constitution of the body.

7. This is a function which is not directly concerned in the office of an organ, but acts in the capacity of an assistant. Thus, the skin is accessory to the lungs.

8. The cellular elements of the body are constantly changing. As long as the protoplasmic liquid of the cell is in motion, the cell has life; but when this ceases, the cell is dead, it is no longer a part of the living body, and is soon removed by the circulation.

9. Areolar tissue is sometimes called cellular tissue, because there are little spaces between the fibers called cells. These contain a serum-like liquid.

10. Basement membranes are thin films of gelatine which support the other membranes.

11. The cells which are imbedded in the basement membrane are called epithelium.

12. The three divisions are called—Hyaline, Elastic, and Fibro cartilage.

13. Muscular tissue is voluntary, and involuntary.

14. Lamellæ are little layers of bone arranged in concentric rings around the tiny canals which pass through the bones.

15. The serous membrane secretes serum; the synovial secretes synovia; and the mucous, secretes mucus. These are viscid transparent fluids.

16. Adipose tissue is a storehouse, it is the system's only nourishment in some diseases. It is not essential to any organ. None is found in the lungs and eyelids.

17. If the synovial membrane is ruptured the synovia penetrates the tissues forming a "weeping sinew."

18. Histology is the microscopic study of the tissues of the body.

LESSON III.

CHEMISTRY OF THE HUMAN BODY.

TOPICAL OUTLINE.

1. **Inorganic Proximates.** (In Combination.)

- 1. Water;
- 2. Phosphates of
  - 1. Lime; 2. Magnesia;
  - 3. Soda; 4. Potassa.
- 3. Carbonates of
  - 1. Lime; 2. Soda; 3. Potassa
- 4. Chlorides of
  - 1. Sodium; 2. Potassium.
- 5. Compounds with
  - 1. Iron; 2. Manganese; 3. Silica.

2. **Inorganic Proximates.** (Free.)

- 1. Oxygen; 2. Nitrogen;
- 3. Carbonic Acid Gas.

3. **Organic Proximates.**

- 1. Nitrogenous Constituents;
  - 1. Albumen;
  - 2. Albuminoids;
    - 1. Albuminose; 2. Fibrin;
    - 3. Musculin; 4. Casein;
    - 5. Pepsin; etc.
- 2. Non-Nitrogenous Constituents;
  - 1. Fats;
    - 1. Olein; 2. Margarin.
  - 2. Sugars;
    - 1. Glucose; 2. Lactin.
  - 3. Starch.

SUPPLEMENTARY.

QUESTIONS.

1. What are proximates?
2. Explain the difference betwen the two classes of proximates.
3. What is a phosphate?
4. What is a base?
5. What is a carbonate?
6. What is a chloride?
7. Is chloride of sodium (common salt) really a part of the body?
8. What is a fluoride?
9. What is the chemical composition of carbonic acid gas?
10. Into what two classes are the non-nitrogenous elements divided?
11. What are hydrocarbons and carbohydrates?
12. What per cent. of the human body is oxygen? What per cent. is carbon?
13. How are the names of substances symbolically written in chemistry?
14. What are the symbols for water? Carbonic acid?
15. What is an atom?
16. What is a molecule?

ANSWERS.

1. The proximate or fundamental principles of the human body are those elements which cannot be separated into simpler forms without the aid of chemical analysis.
2. The inorganic proximates are those which are derived from the natural elements. The organic are those which have been transformed by assimilation in plants or animals.
3. A *phosphate* is a salt formed by the union of phosphoric acid with some substance called a base.
4. A *base* is a substance which has the power of neutralizing acids. It is a metal, or something which is acted upon by the acids like a metal. The product of this union is a salt.

5. A *carbonate* is a salt formed by the union of carbonic acid and a base.

6. A *chloride* is a salt formed by the union of chloric acid with a base. Chloride of sodium is *common salt.* It is formed from chloric acid and a metal called sodium. Nature has formed it in great abundance.

7. Chloride of sodium is not really a constituent of any of the tissues of the body but is found in a free state everywhere—aiding in removing the worn out matter. It is also an auxiliary in the processes of digestion.

8. A *fluoride* is a compound formed by flourine (which is an element related to oxygen) and a metal base.

9. Carbonic acid is composed of one part of carbon and two parts of oxygen. It is more technically called carbon dioxide. It readily combines with water, and when exhaled it contains two parts of hydrogen, one of carbon and three of oxygen.

10. They are called hydrocarbons and carbohydrates.

11. The chemical composition of the hydrocarbons is two atoms of oxygen and four of hydrogen to the molecule. They are the fats of the body, and are the source of heat. The carbohydrates are formed by combining oxygen with carbon and hydrogen. They are the sugars of the body.

12. About 72 per cent. of the body is oxygen, and 13.5 per cent. is carbon.

13. By symbols consisting generally of the initial letters of the names of the elements which compose them, with a small subfigure denoting the number of atoms in a molecule.

14. The symbol for water is H_2O—which means that two atoms of hydrogen unite with one of oxygen to form the molecule, Carbonic acid—CO_2.

15. Atoms may be defined as the *individual constituents* of matter. They are the elements which produce chemical changes. Their existence, however, is theoretical.

16. The union of atoms in certain proportions forms a molecule, and this is the basis of all material substances.

LESSON IV.

THE OSSEOUS SYSTEM.

TOPICAL OUTLINE.

1. **The Skeleton.**
   1. Definition; 2. Number of Bones.
2. **Uses of Bones.**
   1. Protect Organs; 2. Produce Motion;
   3. Preserve Shape of Body.
3. **Form.**
   1. Long; 2. Short; 3. Flat; 4. Irregular.
4. **Composition.**
5. **Structure.**
   1. Mechanical;
      1. Osseous Tissue; 2. Medulla;
      3. Periosteum.
   2. Microscopic;
      1. Lacunæ; 2. Canalicula;
      3. Haversian Canals.
6. **Growth.**
7. **Repair.**
   1. Nature's Provisions;
   2. Mechanical Appliances.
8. **Joints.**
   1. Kinds;
      1. Hinge; 2. Ball-and-Socket; 3. Rotary.
   2. Cartilage;
      1. Arrangement; 2. Use.
   3. Synovial Membranes;
   4. Ligaments;
      1. Capsular; 2. Funicular.
9. **Classification of Bones.**
   1. Head;
      1. Skull; (Use and Structure.)
         1. Frontal; 2. Parietal; 3. Temporal.
         4. Occipital; 5. Sphenoid; 6. Ethmoid.

2. Face;
   1. Superior and Inferior Maxillary;
   2. Malar; 3. Palatal; 4. Lacrymal;
   5. Turbinated; 6. Nasal; 7. Vomer; 8. Hyoid.
3. Ear;
   1. Malleus; 2. Incus; 3. Stapes.

2. Trunk.
1. Chest; 2. Abdomen;
3. Spine (Vertebræ.)
   1. Cervical; 2. Dorsal; 3. Lumbar.
4. Ribs;
   1. True; 2. False; 3. Floating.
5. Sternum;
6. Pelvis;
   1. Sacrum; 2. Innominata; 3. Coccyx.

3. Upper Extremities;
1. Shoulder;
   1. Clavicle; 2. Scapula.
2. Arm;
   1. Humerus; 2. Ulna; 3. Radius.
3. Hand;
   1. Carpus; 2. Metacarpus; 3. Phalanges.

4. Lower Extremities;
1. Leg;
   1. Femur; 2. Patella; 3. Tibia; 4. Fibula.
2. Foot;
   1. Tarsus; 2. Metatarsus; 3. Phalanges.

10. **Special Description.**
   1. Shoulder Joint; 2. Elbow; 3. Wrist;
   4. Hand; 5. Hip Joint; 6. Knee; 7. Foot.

11. **Hygiene.**
   1. Correct Positions; 2. Exercise;
   3. Deformities;
      1. Cause; 2. Prevention; 3. Treatment.

12. **Diseases.**
   1. Rickets; 2. Felon; 3. Curvature of Spine;
   4. Bow Legs; 5. Dislocations; 6. Sprains.

SUPPLEMENTARY.

QUESTIONS.

1. Why do physiologists differ as to the number of bones in the body?
2. If a bone be removed, and the periosteum left, uninjured, what will be the result?
3. Why are the Haversian canals so called?
4. What are the common names for the bones of the ear?
5. What part of the composition of a bone is mineral matter?
6. What is meant by "breaking the neck?"
7. What is a sprain? a fracture? a dislocation?
8. Why is the sacrum so called?
9. What is an immovable joint? Give an example.
10. What and where is the calcis?
11. What is schindylesis?
12. What is the socket for the head of the thigh bone called?
13. Why is the shoulder more easily dislocated than the hip?
14. Why did nature make a difference in the construction of these joints?
15. How does the skull articulate with the spine?
16. What and where is the astragulus?
17. Describe the lacunæ; the canaliculi.
18. What is a fontanel?
19. What is a planiform joint?
20. What is the endosteum?
21. In the scientific description, what names are given to the eminences or "processes," of the bones?
22. What names are given to the depressions?
23. What do the names, endoskeleton, exoskeleton, and mezzoskeleton, signify?
24. What are sesamoid bones?
25. What are wormian bones?
26. What are the trochanters?
27. What is osteology?
28. What is arthrology?

29. Into what three parts is the sternum divided?

30. Into what three divisions is each innominatum divided?

31. How strong is a bone when compared with oak timber?

ANSWERS.

1. Some authors count the largest of the sesamoid bones, such as the patellæ. Some classify the teeth as bones. Others divide the innominata into their sections.

2. If a bone be removed it will be reproduced again if the periosteum has not been destroyed. Also, if the periosteum be injured, or removed from a healthy bone, the bone will decay.

3. They are so called from Havers, their discoverer.

4. The English words for malleus, incus and stapes are—hammer, anvil and stirrup, by which names they are frequently designated.

5. In youth, the animal matter is in excess, but in old age the mineral matter predominates. The average composition is thirty-three per cent. of animal matter and sixty-seven per cent. of mineral. One-half of the mineral matter is phosphate of lime.

6. The "breaking of the neck" is a dislocation of the atlas and axis vertebræ.

Death is caused by the slipping of the peg of the axis into the medullary canal, thus severing the spinal cord.

7. A sprain is the rupturing of the ligaments about a joint.

A fracture is the breaking of a bone.

A dislocation is the displacement of the bones at the joint. They are said to be "out of joint."

8. So called because the Ancients offered it in sacrifice.

9. Immovable joints are those articulations of bones that are interlocked like a seam.

The seams are called *sutures,* and are found in the skull.

10. The calcis is the heel bone.

11. Schindylesis is that form of articulation in which the sharp edge of one bone fits into the grooved edge of another.

The sphenoid and ethmoid bones are articulated in this way.

12. It is called the acetabulum, and was so named because of its resemblance to the vinegar cup of the Ancients.

Acetum is the Latin for vinegar.

13. The socket into which the humerus articulates is more shallow than that of the femur, and is hence more easily wrenched out.

14. In these joints nature has two great ends to accomplish, viz.: strength and freedom of motion.

A deep cavity gives strength, but interferes with the freedom of motion, while a shallow cavity has less strength but freer motion. In the shoulder freedom of motion is of the highest importance, while in the hip strength is the first requisite.

15. The upper vertebra, called the atlas, has two cavities neatly packed with synovial membrane upon which the lower projections of the skull rest. Upon these surfaces the head can move in any direction.

The atlas vertebra is so called because the Ancients believed that the globe was supported on the shoulders of the God, Atlas.

16. The astragalus is that one of the tarsal bones with which the tibia articulates.

17. If a transverse section of a bone be made, little cavities called lacunæ (little lakes), will be found; these communicate with each other and with the Haversian canals by means of tiny tubes, called canaliculæ (little canals).

18. At birth, the bones of the cranium are not completely ossified. At the union of the angles of the bones, little cartilaginous membranes (which afterward ossify) are found; these are called *fountanels.*

19. The planiform joint is one plane surface gliding upon another, as the clavicle and sternum.

20. The medullary cavity of a bone has a lining similar to the periosteum; it is called the endosteum. Periosteum

meaning around a bone, and endosteum meaning within a bone.

21. When the eminences are broad, rough and uneven, they are called *tuberosities;* when small they are *tubercles;* when sharp and slender they are *spines;* when in narrow ridges, they are *lines.*

22. When the depressions are narrower at the bottom than the entrance, they are called *fossae;* when long and narrow, they are *fissures;* when they are openings which pierce the bones they are *foramen;* when mere indentations they are *notches.* When fissures are wide, they are *grooves.*

23. The body has three supports, viz.: the long framework, or endoskeleton; the skin, or exoskeleton; and the connective tissue, or mezzoskeleton.

24. These are small bones found at the joints. The most notable examples are the patellæ.

25. These are small bones found in the sutures of the skull.

26. At the upper extremity of the femur are two large eminences, *"processes,"* to which large muscles that rotate the thigh are attached. These are called the trochanters.

27. Osteology is that department of Physiology which treats of the bones.

28. Arthrology treats of the joints.

29. The Ancients saw in the sternum, a similarity to a short sword they used, and called one end the *manubrium,* or handle; the middle, the *gladiolus,* or blade; and the other end, the *ensiform appendix,* or point of the sword. These divisions are not real.

30. In youth this bone may be separated into three parts, which are called respectively, the *ilium,* the *ischium,* and the *pubes.*

At maturity they become united into one bone, though complete ossification does not take place for several years.

31. A bone in middle age is twice as strong as a piece of oak timber of the same size.

LESSON V.

MUSCULAR SYSTEM.

TOPICAL OUTLINE.

1. **Use.**
   1. Symmetry; 2. Protection; 3. Motion.
2. **Contractility.**
3. **Arrangement and Number.**
4. **Kinds.**
   1. As to Control;
      1. Voluntary; 2. Involuntary.
   2. As to Direction;
      1. Flexors; 2. Extensors.
   3. As to Form;
      1. Long; 2. Broad; 3. Circular.
5. **Structure.**
   1. Mechanical; 2. Microscopic.
6. **Tendons.**
   1. Mode of Attachment.
   2. Arrangement.
7. **Levers.**
   1. Formation;
   2. Classes;
      1. First; 2. Second; 3. Third.
   3. Advantage of Levers.
8. **Enlargement of Bones at Joints.**
9. **Phenomena.**
   1. Standing Erect;
   2. Walking; 3. Running;
   4. Skill; 5. Dexterity;
   6. "Muscular Sense."

10. Classification.

1. Head;
   1. Occipito—Frontalis; 2. Temporal;
   3. Orbicularis Palpebrarum; 4. Masseter;
   5. Sterno-Cleido-Mastoid; 6. Orbicularis Oris.
2. Trunk (Anterior Part);
   1. Pectoralis Major; 2. Pectoralis Minor;
   3. Obliquus Externus; 4. Obliquus Internus;
   5. Serratus Magnus; 6. Rectus Abdominalis
3. Trunk (Posterior Part);
   1. Trapezius; 2. Rhomboideus Major;
   3. Serratus Posticus Inferior;
   4. Latissimus Dorsi.
4. Upper Extremities;
   1. Deltoid; 2. Biceps Flexor Cubiti;
   3. Triceps Extensor Cubiti;
   4. Supinator Longus; 5. Pronator radii Teres;
   6. Flexor Carpi Ulnaris; 7. Palmaris Longus;
   8. Flexor Carpi Radialis.
5. Lower Extremities;
   1. Femoris Rectus; 2. Crureus; 3. Sartorius;
   4. Vastus Internus; 5. Vastus Externus;
   6. Adductor-Longus, Magnus, Brevis;
   7. Triceps Abductor Femoris;
   8. Gastrocnemius Externus;
   9. Tibalis Antecus;
   10. Flexor Longus Pollicis Pedis;
   11. Extensor Longus Digitorum Pedis.

11. Hygiene.

1. Proper Exercise; 2. Improper Exercise;
3. Time for Exercise; 4. Necessity of Rest;
5. Correct Positions; 6. Kinds of Exercise;
7. Place for Exercise.

12. Diseases.

1. St. Vitus' Dance;
2. Convulsions; 3. Locked Jaw;
4. Gout; 5. Rheumatism;
6. Lumbago; 7. Ganglion.

SUPPLEMENTARY.

QUESTIONS.

1. What is the perimysium?
2. What is meant by the insertion of a muscle?
3. What are adductor and abductor muscles?
4. What are pronator and supinator muscles?
5. What is muscular sound?
6. How are muscles classified with regard to their form?
7. Describe the structure of a muscle.
8. Why is the *tendon of Achilles* so called?
9. What is the myolemma?
10. Why does it rest us to change our work?
11. What are sphincter muscles?
12. How many single muscles are found in the entire body?
13. What is meant by the origin of a muscle?
14. Why does a heavy blow on the head cause one to fall instantly?
15. How are muscles subdivided with respect to their form?
16. What are fasciæ?
17. What causes the difference of color in the flesh of a fowl?
18. What are aponeuroses?
19. What do the words congenerous and antagonistic mean?
20. What tension can the tendon of the heel sustain?
21. A person lost in the woods or on a prairie will nearly always travel in a circle; can you explain this?
22. What are the longest, and shortest muscles of the body?
23. What is a bursa?
24. What class of lever do we employ when we stand on tip-toe?
25. What class is employed when raising a weight in the hand?
26. What is an illustration of a first class lever?

27. Can you give any instances of great muscular strength and endurance?

28. Can you give an instance of the rapidity of muscular action?

29. What is Pathology?

30. What is Myology?

31. What are atrophied muscles?

32. How do we become fatigued?

ANSWERS.

1. Every muscle is surrounded by a membrane of areolar tissue called the perimysium. It corresponds to the periosteum in the bones.

2. That end of a muscle which moves the part to which it is attached is called the insertion. Thus, the biceps has its insertion in the ulna.

3. The muscles which move the limbs *toward* the body are called the adductors; those which move them *from* the body are called abductors.

4. Muscles which turn a part so as to face downward are called pronators; those which turn a part so as to lie on its back are called supinators.

5. If the ear be placed upon the masseter (muscle of the lower jaw) and the teeth be firmly set, a peculiar sound will be heard. The philosophy of this is not very well understood.

6. When the fibers are longitudinal and terminate in the extremities they are called fusiform; when arranged like the rays of a fan they are radiate; when like one side of a feather they are peniform; when like an entire feather they are bipeniform.

7. A muscle is composed of bundles of fibers called fasciculi; each bundle is composed of smaller fasciculi; each smaller fiber is composed of filaments called fibrillæ.

8. A fable says that the mother of Achilles dipped him in the river Styx, which made every part of his body invulnerable except the heel by which she held him. Paris having discovered this vulnerable spot, there directed his fatal arrow.

9. Around every fasciculus there is a thin transparent covering called the myolemma. The smallest fibers are inclosed by it.

10. A change of work means, in nearly every case, a change of muscles employed. Hence, the muscles which were fatigued now have an opportunity to recover and we feel "rested."

11. A muscle which has a circular direction like the muscle around the mouth, is called a sphincter, also called orbicular.

12. There are only five single muscles in the body. Five hundred and twenty-two distinct muscles are arranged in pairs.

13. The origin of a muscle is that end which is fixed, and toward which the muscle contracts.

14. A blow on the head, or any sudden jar of the brain, causes it, temporarily, to lose its functions of governing the body. The sudden relaxation of the muscles causes the fall.

15. They are superficial, and deep-seated, according to their position.

16. They are strong, inelastic membranes surrounding the muscles, and binding the bundles of fibres firmly together.

17. The large muscles of the breast of a fowl are designed to move the wings in flight. The domesticated bird finds but little use for these muscles, and so, but a small supply of blood is required for their repair. The color is due to the small amount of blood which circulates there.

18. Aponeuroses are broad, flat bands of fibrous tissue which form the connections between the muscles and bones. The name is also applied to those tissues which support other organs, and is then synonymous with fasciæ.

19. Those muscles which *pull* in the same direction are called congenerous. Those which act against each other are called antagonistic.

20. This tendon will bear a strain of 1,000 pounds.

21. It is a very uncommon thing to find a person in whom both sides of the body have an equal muscular de-

velopment. The side which is the stronger will *outwalk* the other side, and cause one to travel in a circle.

22. The sartorius, or tailor muscle, is the longest muscle of the body; the stapedius, in the middle ear, is the shortest.

23. A bursa is a small sack, secreting a lubricating fluid which reduces the friction where the tendons pass over hard surfaces.

24. The second class.

25. The third class.

26. Striking a blow with the fist, from the shoulder, is an example of a first-class lever.

27. Milo, the Grecian athlete, is said to have shouldered a live ox and carried it through the stadium of Olympia. Edward Balmont, a Frenchman, traveled on foot from Paris to Chamonix, a distance of 340 miles, in five days; the pedestrian, Weston, of our own country, traveled 100 miles in one day.

28. It is estimated that the fingers of a skillful pianist make 1,000 different movements in a single minute.

29. Pathology is the science which treats of diseases.

30. Myology is that department of Physiology which treats of the muscles.

31. A muscle, which, through disuse or disease, dwindles away until it is unable to perform the work for which it was originally designed, is said to be atrophied. There are three atrophied muscles in the external ear, from which it would seem that in ages gone by our ancestors were able to move their ears.

32. In exercise, the muscles become destroyed by disintegration. When this takes place faster than it can be repaired, the muscle becomes fatigued. Rest is necessary to restore the muscle.

LESSON VI.

THE INTEGUMENTARY SYSTEM

TOPICAL OUTLINE.

1. **The Skin.**
2. **Description.**
3. **Structure.**
   - 1. Cutis;
     - 1. Use; 2. Structure;
     - 3. Papillæ.
   - 2. Cuticle;
     - 1. Formation; 2. Variance.
   - 3. Use and adaptation of Cuticle;
   - 4. Complexion;
     - 1. Blonde; 2. Brunette.
   - 5. Discoloration;
     - 1. Tan; 2. Freckles.
4. **Modification of Cuticle.**
   - 1. Hair;
     - 1. Use; 2. Structure;
     - 3. Growth; 4. Care.
   - 2. Nails;
     - 1. Use; 2. Growth;
     - 3. Matrix; 4. Care.
5. **Mucous Membrane.**
   - 1. Structure; 2. Secretion.
6. **Connective Tissue.**
7. **Modifications of Mucous Membrane.**
   - 1. Teeth;
     - 1. Classification;
       - 1. Incisors; 2. Canines;
       - 3. Bicuspids; 4. Molars.
     - 2. Parts;
       - 1. Crown; 2. Neck; 3. Root.
     - 3. Articulation.

7. Modifications of Mucous Membrane—*Continued.*

1. Teeth;
   - 2. Temporary Teeth;
   - 3. Permanent Teeth;
   - 4. Structure;
     - 1. Dentine; 2. Enamel;
     - 3. Cement; 4. Nerve.
   - 5. Decay; 6. Preservation.

8. Glands of the Skin.

- 1. Oil Glands;
  - 1. Secretion; 2. Ducts.
- 2. Perspiratory glands;
  - 1. Size; 2. Form;
  - 3. Perspiration;
    - 1. Composition; 2. Use.
- 3. Absorption.

9. Hygiene.

- 1. Bathing;
  - 1. Proper time;
  - 2. Cold Water Bath;
  - 3. Warm Water Bath;
  - 4. Reaction;
  - 5. Use of Soap.
- 2. Sea Bathing;
- 3. Clothing.
  - 1. Relative Merits of—
    Linen, Cotton, Woolen.
  - 2. Effect of Color.

10. Diseases.

- 1. Erysipelas; 2. Chilblains;
- 3. Eczema; 4. Ingrowing Nails;
- 5. Dropsy; 6. Wens;
- 7. Corns; 8. Warts.

SUPPLEMENTARY.

QUESTIONS.

1. What other names are applied to the cuticle?
2. What is probably the cause of the difference of complexions in the races?
3. Can a negro stand more heat than a white person?
4. What are Albinos?
5. Which eliminates the greater amount of impurities from the body, the skin or the lungs?
6. How is the body kept cool in hot weather.
7. Which is the harder, the enamel of a tooth or a file?
8. Of what is enamel composed?
9. What is gomphosis?
10. A severe wound upon a negro will leave a white scar. Why?
11. What fact concerning our food is suggested by the variety in the structure of our teeth?
12. What causes hair to turn gray?
13. Explain the structure of a hair.
14. What does the term "appendages of the skin" include?
15. If a tooth be extracted and replaced in its socket will it grow fast again?
16. What causes the hair to stand on end. What purpose does this serve in the economy of nature in the animal kingdom?
17. Is a blanket, loosely woven, warmer than one of the same material closely woven?
18. Is the oilcloth upon the floor colder than the carpet?
19. Does color in cloth have anything to do with its usefulness as clothing?
20. To add to the splendor of a Roman jubliee, a child was covered with gold-leaf. In a few hours its death occurred. Can you explain the cause?
21. Can skin be *transplanted* from one part of the body to another?

ANSWERS.

1. It is often called the scarf-skin, and epidermis.

2. In the natural distribution of the earth's inhabitants, we find a striking coincidence between dark skin and hot climates. A people exposed to a tropical sun soon become *tanned,* and in the course of a few generations it will be found that their color of skin is a shade darker than it was originally. Also, it has been observed that the skin of the African loses its shining blackness after a few generations of life in the temperate zones. This may explain why some people are dark, and others white.

3. The heat from the sun (luminous heat) readily penetrates the white transparent skin of the white man, but the pigment in the skin of the negro affords a screen which effectually absorbs and reflects the rays of the sun. Sit before a window through which the sun shines, then lower the curtain and notice the difference of the sun's heating effect upon you. You now have a good illustration of the effect of color in skin.

4. A certain disease, found among persons of dark skin, causes the disappearance of the pigment, leaving the skin, the hair, and the shaded portions of the eyes, colorless. These people are called Albinos.

5. It is estimated that the relative proportions of impurities thrown off by the skin and lungs, are as 23 to 14.

6. Water in evaporating, absorbs a large amount of heat. When the temperature of the body rises on account of external or internal heat, the perspiration becomes more copious, the evaporation of which extracts heat from the body and thus reduces its temperature. As soon as the body cools perspiration diminishes.

7. A tooth will make a dent in the hardest steel file. Such experiments, however, should not be attempted, as the enamel may thus be cracked—an injury which nature will never repair.

8. The enamel is not bone, as it appears to be, but a very compact form of the mucous membrane. Strange as it may seem, the same cells which form the softest membrane also form the hardest and most enduring substance in the body.

9. The articulation which the teeth make with the jaw is so called, because it is like a nail driven into wood. *Gomphos,* is a Greek word meaning nail.

10. The pigment, which gives the black color to the skin, is deposited in the cutis just under the cuticle. A severe wound will destroy the true skin, and, when this is once destroyed, it will never be replaced. The "skin" which is formed over a wound contains none of the characteristics of the original skin.

11. The food of an animal may be determined by the formation of its teeth. Thus, a carnivorous animal has canines for *tearing;* an herbivorous animal, molars for *grinding,* and incisors for *cutting,* but no canines. The fact that we have all these teeth indicates that our diet is mixed. That is, we are omnivorous.

12. The color of the hair is due to the pigment deposited in the cortical layer. When this deposit ceases the hair turns white.

13. A hair is a hollow shaft composed of two layers; the outer one is called the *cortical,* and the inner the fibrous layer. The canal is filled with a medullary substance. The shaft is made up of little plates of horn-like material which overlap each other like the shingles of a roof.

14. Speaking of the animal kingdom, it includes hair, nails, horns, hoofs, scales (of fishes), and feathers. It seems at first almost incredible that the same tiny plates which form the beautiful and delicate skin, should be capable of such wonderful transformations, and that this variation should be due to their arrangement, and compactness.

It is, however, not stranger than the fact that the same material which forms the paper upon which we write can be made into a car wheel; a water bucket; or, in fact, almost any article which requires strength and durability of substance.

15. Skillful dentists frequently extract teeth that are ulcerated at the root, and, after cleansing them, replace them. If the tooth was otherwise healthy and the cement has not been seriously injured, it will soon become fastened in the bone. Even the little nerve which has been divided may unite again.

16. There is a little muscle attached to the root of every hair, which, when stimulated by cold or other sensation, contracts and causes the hair "to stand on end." In this way animals change the thickness of their coats, and are enabled to withstand sudden changes of temperature.

17. The loosely woven blanket is the warmer. This is because there is more air between the fibers, and air being a nonconductor of heat, is itself a blanket. Hence, if two blankets are made of the same quality and quantity of material, the one which is loosely woven is really the thicker. See question 16, last part.

18. It is not, as can readily be proved by means of a thermometer. The thermometer, however, when placed upon the oilcloth will fall more rapidly than when placed upon the carpet. This proves that the former is a better *conductor* of heat, and by extracting the heat from the body much more rapidly gives the sensation of greater cold.

19. Light colored clothing is best for general purposes. Light shades of coloring matter in any substance make it a reflector, or non-conductor of heat (as well as light). Dark colored cloth absorbs heat and is a better conductor; in cold weather it carries the heat from the body, and in very hot weather, this is reversed.

20. The gold-leaf was made to adhere closely to the skin, thus hermetically sealing up the pores. In this condition the child really died of suffocation, as the lungs were overburdened (see question 5), and unable to accomplish the purification of the blood. The Romans, however, thought that the Deity had taken this means of showing his displeasure.

21. This can easily be performed and is frequently done to heal an otherwise incurable wound. Skin from a fowl is often used for this purpose. A portion, of course, is selected which bears no feathers, for any skin, wherever planted, would bear the same appendages as it did in its original situation, just as a graft on a fruit tree bears the fruit of the parent tree.

LESSON VII.

THE RESPIRATORY SYSTEM.

TOPICAL OUTLINE.

1. **The Voice.**
   - 1. Description;
   - 2. Organs;
     - 1. Larynx;
       - 1. Glottis; 2. Epiglottis.
     - 2. Vocal Cords.
   - 3. Modulations;
     - 1. Falsetto; 2. Change of Voice.
   - 4. Speech;
     - 1. Vocal; 2. Whisper.
   - 5. Articulate Sounds;
     - 1. Vowels; 2. Consonants

2. **Trachea.**
   - 1. Description;
     - 1. Bronchi;
     - 2. Cartilaginous Rings.

3. **Lungs.**
   - 1. Description;
   - 2. Difference of Structure;
   - 3. Pleura; 4. Cilia;
   - 5. Air Cells;
   - 6. Breathing;
     - 1. Inspiration;
     - 2. Expiration.
   - 7. Modifications of the Breath;
     - 1. Sighing; 2. Coughing;
     - 3. Sneezing; 4. Snoring;
     - 5. Laughing; 6. Crying;
     - 7. Hiccoughing; 8. Yawning.

4. **Auxiliary Organs.**
   - 1. Diaphragm; 2. Ribs;
   - 3. Muscles

5. **Capacity of the Lungs.**
   - 1. Breathing Capacity; 2. Limits;
   - 3. Value of Fresh Air;
   - 4. Action of Air in Lungs;
   - 5. Tests for Carbonic Acid Gas;
   - 6. Effects of Rebreathing Air;
     - 1. Stagnation of Blood;
     - 2. Diseases; 3. Death.

6. **Types of Respiration.**
   - 1. Abdominal; 2. Intercostal.

7. **Frequency Influenced By—**
   - 1. Age; 2. Sex; 3. Sleep.

8. **Ventilation.**
   - 1. Diffusion of Expired Air;
   - 2. Influence of Light;
   - 3. Ventilating Rooms Heated with—
     - 1. Hot Air; 2. Steam; 3. Stoves.
   - 4. Ventilation of Public Buildings;
     - 1. Churches; 2. Schools; 3. Assembly Halls.
   - 5. Shaft-Ventilation.

9. **Phenomena of Respiration.**

10. **Hygiene.**
    - 1. Proper Position;
    - 2. Movements of the Chest;
    - 3. Location of Dwellings;
    - 4. Development of the Respiration;
      - 1. Singing; 2. Speaking;
      - 3. Calisthenic Exercises.

11. **Diseases.**
    - 1. Constriction of the Lungs;
    - 2. Bronchitis; 3. Pleurisy;
    - 4. Pneumonia; 5. Consumption;
    - 6. Asphyxia; 7. Diphtheria;
    - 8. Croup; 9. Stammering.

SUPPLEMENTARY.

QUESTIONS.

1. Are the lungs similar (symmetrical) in form?
2. What is meant by "Adam's Apple?"
3. What names are applied to different parts of the lungs?
4. What is parenchyma?
5. What is thought to be the cause of baldness?
6. Why do we gape when we are sleepy?
7. How do fishes breathe?
8. How do insects breathe?
9. What are infundibulæ?
10. If you ascend a very high mountain, blood will issue from the nose and lips. What causes this?
11. Do we really draw the air into the lungs in breathing?
12. Why does breathing upon a pane of glass leave it moist?
13. If there were a greater proportion of oxygen in the atmosphere what would be its effect upon us?
14. If you cover a frog with dust, it will die. Why?
15. Have accidents ever resulted from violent sneezing?
16. What accident may happen while we are gaping?
17. Could a person live in an atmosphere of pure oxygen?
18. Are the vocal cords really cords?
19. How much oxygen does the blood receive from the air in twenty-four hours?
20. How much carbon does the air receive from the blood in twenty-four hours?
21. What is calorification?
22. What do the terms residual air, complemental air, and supplemental air, mean?
23. Why do people in cities have gray lungs?

24. What is called the "sounding board" of the human voice?

25. Does a fan cool the air?

26. Can you cite any instance where death has been caused by impure air?

27. What is Pneumonology?

ANSWERS.

1. They are not. The right lung is larger than the left and has three lobes, while the left has but two. The greater portion of the blood passes through the right lung.

2. "Adam's Apple" is the prominence in the front of the neck. It is larger in the male than the female.

3. The upper part is called the apex; the middle portion to which the trachea and pulmonary blood vessels extend is called the root; and the lower part is the base.

4. Parenchyma is the substance of which the lungs are composed. It is of a spongy texture made up entirely of blood vessels, lymphatics, bronchial tubes, and nerves.

5. The fact that men generally wear hats of a material which will not permit a free circulation of air seems to explain why baldness is almost exclusively confined to them. The over-heated air injures the hair follicle causing the hair to "die out." When the root of a hair is once destroyed it can never be restored.

6. The desire to gape has its origin in the nerves, which, when fatigued, may be relieved by stretching. This seems to have the same effect upon them as friction does upon the muscles.

7. Fishes breathe by means of gills which are fine networks of connective tissue through which the blood circulates. The free oxygen in the water penetrating through these tiny interstices comes in contact with the blood and purifies (oxygenates) it.

8. In their sides, in the region of the wings, insects have little openings, called spiracles, through which the air is made to pass by a peculiar motion of the abdomen. In

its passage through these tubes the air comes in contact with the blood.

9. The bronchial tubes divide and subdivide many times, finally ending in little pear-shaped cells, which are called infundibulæ.

10. The atmosphere, at the sea level, presses with a weight of fifteen pounds upon every square inch of surface. The reason that we do not feel this pressure is that the air in the tissues of the body exerts an equal pressure, but, when we pass into a high altitude, the external pressure of the air becomes less and the air within expanding, forces itself through the delicate mucous membrane driving the blood out with it.

11. We do not. When the ribs and diaphragm increase the size of the thoracic cavity, the air becomes rarefied, its expansive power becomes less than that of the air without, which rushes in to restore the equilibrium.

12. The expired air contains moisture which condenses upon the pane. A large amount of water laden with impurities escapes from the body in this way. A portion of this moisture combines with the carbon dioxide forming the deadly carbonic acid gas.

13. A fire supplied with a stream of oxygen gas burns with almost inconceivable energy, producing a heat, compared with which, an ordinary fire is quite cool. If the portion of oxygen in the air were greater than it is we would "live faster," our bodily organs would be greatly exhilarated, our minds would also be more active, and very probably, stronger; but the body, for this very reason, would fall into early decay. Our lives would be shortened in proportion to our greater activity.

14. The frog breathes largely through its skin. To facilitate this the skin contains glands that secrete a fluid which keeps it moist. (Have you noticed that the skin of a frog is always wet?) If dust be spread upon the skin the little pores will be clogged, and the frog must die of suffocation.

15. Many people have sustained fractures of the ribs from sneezing. Rupture is often caused by this.

16. If the jaws be distended to their utmost, they may be dislocated, in which case the mouth cannot be closed. If the lower jaw is drawn downward, and then forward, it can be put back into place again.

17. He could not. The unnatural stimulation to which the whole organism would be subjected would soon bring on exhaustion and death.

18. The vocal cords, so called, are merely thin and elastic membranes which are attached to the sides of the larynx.

19. The blood extracts from the air about thirty-seven ounces of oxygen daily.

20. The air receives from the blood about fourteen ounces of carbon daily.

21. Calorification treats of the production of the heat of the body.

22. When we forcibly expel the air from the lungs there is always a considerable amount left, which is called residual air. The quantity of air which can be drawn into the lungs above the usual amount is called complemental air. After an ordinary exhalation, the amount of air that can be expelled by extra force is called supplemental air.

23. The numerous fires produce a large amount of carbonic gases which penetrate the tissues of the lungs. All coloring matters containing disintegrated carbon become, like India ink, indelible.

24. The mouth, nasal passages, and the pharynx, by their resonance, add volume to the sound. The absence of this effect is noticeable when these parts are inflamed by a cold.

25. The fan does not cool the air; but, by setting it in motion, the air as it is heated by the body is driven away while cool air takes its place. The movement of the air also increases evaporation, which absorbs heat.

26. After the battle of Austerlitz, 300 prisoners were confined in a cavern, and in a short time 260 of them died. The suffocation in the "Black Hole," in Calcutta, is another instance.

27. Pneumonology is that department of Physiology which treats of the respiration.

LESSON VIII.

THE CIRCULATORY SYSTEM.

TOPICAL OUTLINE.

1. The Blood.

- 1. Plasma;
  - 1. Fibrin; 2. Albumen; 3. Minerals.
- 2. Corpuscles;
  - 1. Size; 2. Shape; 3. Color.
- 3. Uses and kinds;
- 4. Coagulation; 5. "Transfusion."

2. Organs of Circulation.

- 1. Heart;
  - 1. Description; 2. Movements;
  - 3. Auricles; 4. Ventricles;
  - 5. Valves;
    - 1. Bicuspid; 2. Tricuspid.
    - 3. Semi-Lunar.
  - 6. Valve Supports.
- 2. Arteries;
  - 1. Description; 2. Pulse.
- 3. Veins;
  - 1. Description; 2. Valves.
- 4. Capillaries.

3. The Circulation.

- 1. Pumonic;
  - 1. Pulmonary Artery;
  - 2. Pulmonary Vein;
  - 3. Purification of Blood.
- 2. Systemic;
  - 1. Aorta; 2. Vanæ Cavæ;
  - 3. Transformation in Capillaries
- 3. Portal.

4. Velocity of the Blood.

6. Heat of the Body.

- 1. Source;
  - 1. Oxydization; 2. Disintegration.
- 2. Natural Temperature;
- 3. Distribution; 4. Regulation.

7. Change of the Body.

1. Corrosion; 2. Re-organization.

8. Vital Organs.

1. Cause of Death.

9. Phenomena of the Heart.

1. Power; 2. Constancy.

10. Lymphatic Circulation.

- 1. Description; 2. Glands;
- 3. Lymph; 4. Uses; 5. Lacteals;
- 6. Hibernation of Animals.

11. Principal Arteries and Veins.

- 1. Aorta;
  - 1. Thoracic;
    - 1. Iliac; 2. Femoral; 3. Tibial.
  - 2. Coronary; 3. Gastric; 4. Hepatic;
  - 5. Spleenic; 6. Renal; 7. Spinal;
  - 8. Subclavian; (Right and Light.)
    - 1. Brachial; 2. Radial; 3. Ulnar.
- 2. Venæ Cavæ;
  - 1. Descending; 2. Ascending, Etc.*

12. Hygiene.

- 1. Effects of—
  - 1. Exercise; 2. Chill; 3. Pressure.
- 2. Air and Sunlight.

13. Diseases.

- 1. Congestion; 2. Inflammation; 3. Bleeding;
- 4. Scrofula; 5. Cold; 6. Catarrh.

*In general, the arteries and veins have the same names, and these names are taken from the organ, or part of the body, at which they are located.

SUPPLEMENTARY.

QUESTIONS.

1. What has been called the "tripod of life?"

2. Does the temperature of any part of the body rise above blood heat?

3. If the energy of one's heart could be applied to a machine, how high could it lift him in a day?

4. Does the heart ever rest?

5. What vein begins and ends in capillaries?

6. Which side of the heart is the most liable to become inflamed?

7. What is the function of the red corpuscles?

8. What is the function of the white corpuscles?

9. To what is the difference in color of the blood due?

10. What is the "Circle of Willis?"

11. What is meant by anastomosis?

12. What may greatly increase the number of white corpuscles in the blood?

13. Do the corpuscles have movements of their own?

14. How do the number and capacity of the arteries compare with the veins?

15. What is the color of the blood of insects?

16. Can you illustrate the velocity of the blood?

17. If you place your fingers in your ears you will hear a roaring sound. What causes this?

18. Are the chambers in the heart of the same shape?

19. Can you trace the portal circulation?

20. How is circulation produced in the lymphatics?

21. Is the heart on the left side?

22. How many openings has the heart?

23. Can there be any pain in the heart?

24. Where are the red corpuscles disorganized?

25. What is hæmaglobin?

26. What three nerves does the heart receive from the spinal cord and medulla, and what are their actions?

27. What is Angiology?

ANSWERS.

1. The lungs, heart, and brain are called the "tripod of life." By this we mean that if either of these organs should cease to perform its work, death would follow. It has been proved, however, that if circulation and respiration are maintained by artificial means, the brain may be removed without causing death.

2. In the hepatic vein the temperature rises to 106° Fahrenheit.

3. It would raise him to the height of 1,250 feet. The energy of this little "muscular pump" is almost incomprehensible; it can do (in proportion to its weight) ten times as much work as a steam engine.

4. Between the beats the heart takes a short rest. Whatever is done in the way of repair, is accomplished in this brief space of time. It is believed that the heart changes its entire substance several times in a year. Rest is essential to every organ; repair cannot be accomplished while it is in action.

5. The portal vein begins with capillaries in the digestive apparatus and ends in capillaries in the liver.

6. The left side. This side is strained by a great amount of labor, and contains the active, oxygenated blood.

7. It seems to be the function of the red corpuscles to carry oxygen to the tissues, by means of which, the worn out portions are decomposed (disassimilated). These portions thus cut out are eliminated by the several excretory organs.

8. The white corpuscles are assimilated into the tissues. They are the means by which the body is constantly being repaired.

9. The red color is due to the presence of oxygen in the corpuscles; the color of the venous blood is due to the carbonic acid it contains.

10. This is a ring of arteries formed at the base of the brain by the anastomosing of the branches of vertebral and carotid arteries. By this provision two routes are open from the aorta to the brain, so that in case one should be obstructed the brain could be supplied by the other. Nature has here made a double provision to guard against accident, for a sudden change in the supply of blood to the brain would be attended with serious consequences.

11. The intercommunication of arteries by means of special connecting tubes is called anastomosis. If a large artery should be tied (to stop bleeding) or otherwise obstructed, these connecting tubes would rapidly become enlarged and continue the circulation.

12. When there is inflammation in any part of the body the number of white corpuscles is greatly increased to meet the demand for the repair necessary to restore the rapidly wasting tissues. Also, if a large wound is to healed, the number is increased to make this extra repair.

13. If a drop of fresh blood be placed under a powerful microscope, it will be noticed that the corpuscles move hither and thither as if individually endowed with life and volitional powers. This phenomenon, like many others of a similar nature, is not well understood.

14. The veins are larger and more numerous than the arteries so that their capacity is about four times that of the arteries.

15. The blood of insects is yellowish or entirely colorless. They have a heart and blood vessels, but the latter have not the distinctions of veins and arteries.

16. If the blood could flow in a straight line it would move 150 feet in a minute.

17. This is caused by the circulation of the blood in the fingers and in the ears. When the ears are stopped this sound is concentrated upon the drum.

18. The chambers in the left side of the heart are oval, while those in the right side are triangular.

19. Blood from the aorta passes to the mucous membrane of the alimentary canal; then through the capillaries of this mucous membrane; these capillaries uniting form the portal vein, which passes to the liver; here it divides again into the hepatic capillaries which reuniting form the hepatic vein; this vein returns the blood to the general circulation.

20. The valves in the lymphatic vessels become filled by absorption; the pressure produced by each inspiration and expiration forces the lymph along through the valves which close when the pressure is released. Capillary attraction aids in moving the lymph in the smaller vessels and capillaries.

21. The heart is not on the left side, but directly in the middle of the chest. Its apex points to the left, and as this is the part which throbs, the belief has become popular that the heart is on the left side.

22. There are eight orifices; two, of the venæ cavæ, by which the blood enters the heart; one, of the pulmonary artery, by which it passes to the lungs; four, of the pulmonary veins, by which it returns; and one, of the aorta, by which the blood passes to all parts of the body.

23. The heart is not supplied with nerves of feeling, hence the sensation of pain cannot be communicated from the heart.

24. These corpuscles having served their purposes as transporters of oxygen are destroyed in the liver.

25. These are small particles which float in the blood, and which, when acted upon by the oxygen, change their color to a bright red. See question nine.

26. 1. The *depressor,* which comes from the medulla, commands the heart to beat slowly and powerfully; 2. The *cardio-inhibitory,* which comes from the same source, commands it to beat slowly; 3. The *accelerator,* which comes from the cervicle region of the spinal cord, commands it to beat faster.

27. Angiology is that department of Physiology which treats of the circulation.

LESSON IX.

THE DIGESTIVE SYSTEM.

TOPICAL OUTLINE.

1. **Food.**
   - 1. Use; 2. Oxidation;
   - 3. Food from the Air;
   - 4. Amount;
     - 1. Solid; 2. Liquid.
2. **Kinds of Food.**
   - 1. Nitrogenous;
     - 1. Albumen; 2. Casein; 3. Gluten.
   - 2. Carbonaceous;
     - 1. Sugars; 2. Fats; 3. Starch.
   - 3. Mineral Substances;
     - 1. Sulphur; 2. Salt; 3. Iron; Etc.
3. **Need of Variety in Food.**
4. **Digestion.**
   - 1. Changes Affected;
   - 2. Assimilation of Food.
5. **Processes of Digestion.**
   - 1. Mastication;
     - 1. Saliva; 2. Ptyaline;
     - 3. Swallowing; 4. Oesophagus.
   - 2. Gastric Digestion;
     - 1. Stomach;
       - 1. Structure; 2. Movements; 3. Orifices.
     - 2. Gastric Juice;
       - 1. Composition; 2. Action.
     - 3. Chyme.
   - 3. Intestinal Digestion;
     - 1. Intestines;
       - 1. Structure; 2. Divisions.
   - 4. Liver;
     - 1. Description; 2. Bile.
   - 5. Pancreas;
     - 1. Description; 2. Pancreatic Juice.
   - 6. Chyle.

6. **Absorption.**
   1. Veins; 2. Lacteals;
   3. Portal Vein.
7. **Complexity of Digestion.**
8. **Time for Digestion.**
   1. Meat; 2. Bread; 3. Potatoes; Etc.
9. **Relative Values of Foods.**
   1. Meats;
      1. Beef; 2. Mutton; 3. Lamb; 4. Pork.
   2. Fish; 3. Oysters; 4. Milk;
   5. Cheese; 6. Eggs; 7. Bread; 8. Corn;
   9. Potatoes; 10. Ripe Fruits.
10. **Stimulants.**
   1. Coffee;
      1. Constituents; 2. Caffeine,
   2. Tea;
      1. Theine; 2. Tannin.
   3. Chocolate;
      1. Constituents; 2. Theobromine.
11. **Cooking of Foods.**
   1. Broiling; 2. Boiling; 3. Frying.
12. **Rapid Eating.**
13. **Kinds of Food Required.**
   1. Varies with—
      1. Age; 2. Occupation; 3. Climate.
14. **Time of Taking Food.**
   1. Number of Meals; 2. Lunching;
   3. Effects of—
      1. Care and Grief; 2. Cheerfulness.
15. **The Wonders of Digestion.**
16. **Hygiene.**
   1. Relation of Food to Exercise.
   2. Regulation of Alimentary Canal.
17. **Diseases.**
   1. Dyspepsia; 2. Mumps.

SUPPLEMENTARY.

QUESTIONS.

1. What is the largest gland in the body?
2. What two secretions seem to have the same use?
3. Can you define deglutition, chymification, and chylification.
4. What old rule is it well to observe after-dinner and supper?
5. Since the stomach will digest all tissues, living tissues included, why does it not digest itself?
6. Into what three parts is the small intestine divided?
7. What is Splanchnology?
8. Into what three parts is the large intestine divided?
9. Who, according to Swift, are the three best doctors in the world?
10. What is Ichorology?
11. What is a negative food?
12. What is the mesentery?
13. What are condiments?
14. What is the omentum?
15. What is the vermiform appendix?
16. Why do animals that live in a desert country have humps on their backs?
17. What names are given to animals that make the following the basis of their diets: Flesh, herbs, fruit, insects, all things?
18. Why does boiled water have an insipid taste?
19. Soda water contains carbonic acid, is it therefore unhealthy?
20. Is water which contains animalcules (microscopic animals) dangerous to the health?
21. If you would pick an apple from a tree, and examine it with a microscope, what would you see?
22. What animal can live when turned inside out?
23. How long could a person live without air; sleep; water; or food?
24. What is the average duration of life?

25. What did Linnaeus, the great botanist, call the "food of the gods?"

26. Who was Alexis St. Martin?

27. Animals of the dog and cat species, do not perspire through the skin, so nature has made them drink by "lapping." Can you explain why?

ANSWERS.

1. The liver is the largest gland in the body, weighing about four and one-half pounds.

2. The saliva and pancreatic juice change starch into sugar; they are auxiliaries in other processes of digestion, but the changing of starch into sugar is their main office.

3. Deglutition is the process of swallowing; chymification is converting the masticated food into chyme; chylification is changing the chyme into chyle.

4. "After dinner sit awhile.
After supper walk a mile."

5. The reason why the gastric juice does not act upon the mucous lining of the stomach is not understood. It has been suggested that the circulation in this organ contains an element which resists the action of the digestive fluid.

6. The three parts are called the duodenum, the jejunum, and the ileum.

7. Splanchnology is that part of physiology which treats of the digestive system.

8. It is divided into the coecum, the colon, and the rectum.

9. Dr. Diet, Dr. Quiet and Dr. Merryman.

10. Ichorology treats of the absorption.

11. A negative food is one which delays digestion, rendering it more complete. Coffee and tea are negative foods. They are also called auxiliary foods.

12. The mesentery is a broad fold of membrane in one edge of which the intestines are enveloped, while the other edge is gathered in a sort of "ruffle" and attached to the spinal column.

13. Condiments are those auxiliary foods which give relish to other foods. They are salt, acids, and spices.

14. The omentum is a large fold of membrane which supports the viscera. It is sometimes called the "caul."

15. The vermiform appendix is located at the origin of the coecum, of which it seems to be an atrophied, or rudimentary, prolongation.

16. Animals like the camel, that live in the deserts, having to make long journeys for food, would die on the way of starvation, but for a wise provision of nature. The hump is a store-house of food upon which the animal subsists when the natural supply fails. These animals, also, have stomachs provided with water cells, in which water is stored to be consumed on these same excursions.

17. Flesh eating animals are called carnivorous; those which eat herbs are called herbivorous; those which eat fruit are frugivorous; those which eat insects are insectivorous; and those which eat all things are omnivorous. The human race is omnivorous. Do any of its members *eat insects?* Some barbarous tribes do.

18. When water is boiled the carbonic acid is driven off, causing it to have a peculiar *flat* taste.

19. It is not unhealthy, at least not on this account, but on the contrary it is a wholesome drink. Carbonic acid is only injurious to the respiratory system.

20. Such water is not dangerous to the health unless it is stagnant, and the animalcules have become putrefied. The idea of drinking water of this kind is rather unpleasant, but such water the great bulk of the human family is drinking.

21. You would find that myriads of animals were creeping about upon it. If the microscope is powerful, it will remind you of a meadow in which cattle, sheep, hogs and fowls are moving about. Would it endanger your health to eat this apple without paring it? It would not.

22. The hydra, found in almost every brook, experiences no inconvenience, as far as digestion is concerned, when turned inside out. The alimentary tract is simply a tube whose lining will serve the purposes of an outer skin, while the outer coat has all the absorbing powers necessary for digestion.

23. For want of air, one could not live more than five minutes; for want of sleep, not more than ten days; for want of drink, not more than seven days; and for want of food death would occur in about nine days.

24. The average length of life is thirty-three years. Only one person out of every hundred lives to be seventy years old.

25. The Chocolate. He was so fond of this fruit that he called the tree which bears it (the Cocoa tree) "Theobroma," which signifies, food of the gods.

26. Alexis St. Martin was a Canadian, employed by the American Fur Company. While thus engaged he met with an accidental wound which, when it healed, left an opening into the stomach. Dr. Beaumont made a close examination of the processes of digestion which could be seen distinctly, and upon which experiments could easily be made. Nearly all we know of the wonders of digestion was discovered in these observations.

27. An animal whose skin contains perspiratory glands can rapidly drink a large quantity of cold water with safety; because, when the region of the stomach is cooled, the blood comes to the surface and produces profuse perspiration, the evaporation of which equalizes the temperature and prevents congestion. An animal which does not perspire must drink water slowly, by lapping, or the blood rushing to the surface and meeting with no reaction (not being cooled), would not return quickly enough to prevent congestion. Nature attains her ends by strange and always interesting means. It will pay us and entertain us to inquire into her mysteries. In the study of Physiology, there is a great variety of interesting facts that lend a zest to its perusal. Many subjects for discussion and research will come to the minds of the enterprising teacher and the inquiring pupils. Zoology and Comparative Anatomy offer very fruitful and entertaining fields for investigation.

LESSON X.

THE NERVOUS SYSTEM

TOPICAL OUTLINE.

1. Description.

- 1. White Matter;
- 2. Gray Matter;
- 3. Fibers; 4. Cells;
- 5. Ganglia; 6. End Organs.

2. Brain.

- 1. Description; 2. Structure;
- 3. Enveloping Membranes;
  - 1. Dura Mater;
  - 2. Arachnoid;
  - 3. Pia Mater.
- 4. Divisions;
  - 1. Cerebrum;
    - 1. Description;
    - 2. Divisions;
      - 1. Hemispheres;
        - 1. Lobes.
    - 3. Convolutions.
  - 2. Cerebellum;
    - 1. Description;
    - 2. Divisions.
  - 3. Pons Varolii;
    - 1. Description; 2. Structure.
  - 4. Medulla Oblongata;
    - 1. Description; 2. Divisions.

3. Spinal Cord.

- 1. Description;
- 2. Structure;
  - 1. Gray Matter;
  - 2. White Matter.
- 3. Reflex Action;
  - 1. Natural; 2. Abnormal.

4. The Nerves.

1. Description;
2. Number and Arrangement;
3. Kinds;
   1. As to Use—
      1. Motory; 2. Sensory.
   2. As to Location—
      1. Cervical; 2. Dorsal;
      3. Lumbar; 4. Sacral;
      5. Coccygeal.
4. Systems;
   1. Spinal;
      1. Number; 2. Posterior and Anterior.
   2. Cranial;
      1. Number; 2. Ramifications.
   3. Sympathetic;
      1. Description; 2. Ramifications.
5. Reflex Action;
   1. Description;
   2. Automatically Controls—
      1. Respiration; 2. Digestion; 3. Etc.
6. Transfer of Pain;
   1. Origin; 2. Location;
   3. Effect in Amputation.
7. Crossing of the Nerves;
   1. Effect in Paralysis.

5. Uses of Nervous System.

1. Source of Motion;
2. Source of Sensation;
3. Seat of the Mind;
4. Connects Mind with Body.

6. Hygiene.

1. Mental and Physical Exercise;
2. Sleep; 3. Sunlight.

7. Wonders of the Brain.

SUPPLEMENTARY.

QUESTIONS.

1. Why will a blow in the region of the stomach sometimes stop the heart?
2. If skin from the hand were transplanted to heal a wound on the cheek, where would a touch to the cheek be felt?
3. What is the pons varolii?
4. If the brain receives an injury, will it be felt?
5. What is thought to be the office of the cerebellum?
6. If a barefooted boy should step on a thistle, the foot would be drawn away before he would become conscious of the pain. Can you explain this?
7. What causes one's foot to go to sleep?
8. How do the nerves terminate?
9. What is a plexus of nerves?
10. What is a funiculus?
11. How fast does nerve impulse travel?
12. What is reason?
13. What is instinct?
14. Can you define the terms, hypnotism; mesmerism? Are these phenomena real or imaginary?
15. What is transcendentalism?
16. What is somnambulism?
17. What is neurology?
18. What old eastern story illustrates the power the mind exercises over the body?
19. What is the technical term for brain?
20. What is the corpus callosum?
21. How many lobes does each hemisphere of the brain have?
22. What two animals have heavier brains than man?
23. What are end-organs?
24. What can you say of the value of sunlight?
25. Over what does the vaso-motor nerve center preside?
26. Over what does the sympathetic system of nerves preside?

ANSWERS.

1. The same pair of nerves (the tenth pair) which supplies the stomach, also extends to the heart. Any injury to the former, by sympathy, paralyzes the branch which leads to the latter.

2. The nerve locates sensation where the nerve fibers end. Hence, if this part of the cheek were touched, the nerve would locate the sensation in that part of the body where the nerve fibers originally had their terminations, that is, in the hand.

3. The pons varolii is a mass of intersecting fibers intermingled with gray matter, and forms the bond of union between the several parts of the brain. It connects the cerebrum with the cerebellum behind and with the medulla below.

4. The brain can receive the sensation of pain, but it cannot give rise to it. The nerves alone can give rise to this sensation. Therefore, the brain may be cut or cauterized without the least pain.

5. It is believed that the principal function of the cerebellum is the control of the voluntary muscles.

6. The sensation of pain would be carried to the nearest nerve center which would "reflect" an order to withdraw the foot. All of this would be done before the news of the accident had reached the brain.

7. If pressure is brought upon the nerve, the nervous force will cease to pass through it. If we sit in such a position that the nerve is pressed against the bone, sensation in the foot will cease. The pressure irritates the nerve, and causes a tingling which, by the mind, is located in the foot.

8. In general, nerves terminate in a delicate network of filaments. The motory, and many of the sensory nerves, terminate thus. The special sense nerves end in little bulbs, and in nerve corpuscles. Some of these corpuscles are structureless, while others are composed of concentric layers like an onion.

9. In many parts of the body, the nerves anastamose (forming a little network) in passing from one funiculus to another. This is called a plexus.

10. Several nerves are bound together in a sheath, forming a little bundle, which is called a funiculus. Each fiber in the funiculus is distinct and has no connection with the others.

11. An impulse is transmitted through the nerves at the rate of 100 feet per second.

12. Reason is that power of mind which derives inferences and conclusions from certain manifestations, or things known; traces causes to their effects; and makes deductions from hypotheses. It is this faculty which enables man to make improvements, and to advance in what we call civilization.

13. Instinct is that mysterious endowment of animals by which all their actions and habits of life are controlled. Instinct makes no improvements and does not seem capable of development. Reason and instinct, though differing widely in their dictates, are yet strangely blended, and it is often difficult to tell what is reason, and what instinct.

14. It has long been known that some minds had strange and unaccountable influences over certain others. In France, a man named Mesmer found that he could, at will, exercise a power over wild or vicious animals, which would make them tame and tractable. It was soon discovered that he could, also, completely overcome the volutional powers of some persons, and render them entirely subject to his own will. This phenomenon was, after him, called Mesmerism.

Hypnotism is another name for the same class of phenomena. The reality of these inexplicable powers is admitted by all thinking men. Read Dr. Carpenter's Physiology.

15. Ever since the time of Pythagoras, there have been people who believed that the soul could, during life, leave (transcend) the body and return to it again. This belief has been called transcendentalism, and, strange and preposterous as it may seem, many of the world's greatest thinkers have believed in it.

16. Somnambulism, as the etymology of the word indicates, means walking in sleep.

There are on record many instances where strange and remarkable feats have been performed by persons while their faculties of consciousness were fast asleep. Persons have been known to ascend giddy heights with impunity; to accomplish marvels in works of art; and to execute many other difficult tasks, which they were utterly incapable of performing while awake.

17. Neurology is that department of physiology which treats of the nervous system.

18. It is related that a traveller met the Plague coming from Bagdad. "You have been committing great havoc there," said the traveller, pointing to the city. "Not so great," replied the Plague; "I killed only one-third of those who died; the other two-thirds killed themselves with fright."

19. The brain is technically called the encephalon.

20. The septum which separates the two hemispheres of the brain is called the corpus callosum.

21. Each hemisphere of the brain is divided into three lobes—named, from their positions: anterior, middle, and posterior.

22. The elephant and the whale.

23. The terminations of the sensory nerves are called end-organs. See answer to question 8.

24. The value of sunlight can scarcely be overestimated. A plant which grows in a cellar has a sickly appearance. Almost its entire structure is composed of water. People who live in dark places, by degrees lose their inherent vitality and mental power. Food is scarcely more imperative than sunshine.

25. This nerve center presides over the arterial system where it causes contraction or relaxation of the walls of the capillaries. When the functions of this center are deranged, it loses its power and "Vascular Enlargement" ensues.

26. The sympathetic presides over the involuntary processes of the body such as respiration, circulation, and digestion. This system also controls the secretions of the glands and regulates the blood supply to the different organs. This system has many nerve centers called ganglia through which a close sympathy is established with all the organs.

LESSON XI.

THE SPECIAL SENSES.

TOPICAL OUTLINE.

1. **Touch.**
   - 1. Location;
   - 2. Special Development;
   - 3. Papillae; 4. Uses;
   - 5. Sensations Produced by—
     - 1. Pressure; 2. Temperature; 3. Pain.

2. **Seeing.**
   - 1. Parts of the Eye;
     - 1. The Three Coats;
       - 1. Sclerotic;
       - 2. Choroid;
       - 3. Retina.
     - 2. Cornea;
       - 1. Location; 2. Form.
     - 3. Iris;
       - 1. Location; 2. Movements.
     - 4. Optic Nerve;
     - 5. Crystalline Lens;
       - 1. Structure; 2. Use; 3. Position.
     - 6. Humors;
       - 1. Aqueous; 2. Vitreous.
     - 7. Eyelids; 8. Eyelashes;
     - 9. Lachrymal Apparatus.
   - 2. Muscles of the Eye;
   - 3. Structure of the Retina;
     - 1. Nerve Cells; 2. Granular Bodies;
     - 3. Rods and Cones; 4. Blind Spot;
     - 5. Yellow Spot.
   - 4. Philosophy of Seeing;
   - 5. Near and Far Sight;
     - 1. Cause; 2. Remedy.
   - 6. Color Blindness.
   - 7. Care of the Eyes.

3. **Taste.**
   - 1. Location;
     - 1. Tongue;
       1. Structure;
       2. Gustatory Nerve;
       3. Lingual Nerve;
       4. Action of Papillae.
     - 2. Palate.
   - 2. Cause of Taste; 3. Uses.

4. **Smell.**
   - 1. Location;
   - 2. Olfactory Apparatus;
     1. Olfactory Nerve;
     2. Olfactory Chambers.
   - 3. Mucous Membrane;
   - 4. Uses;
   - 5. Structure of the Nose;
     - 1. Nasal Passages;
     - 2. Nasal Openings;
       1. Anterior; 2. Posterior.

5. **Hearing.**
   - 1. Divisions of the Ear;
     - 1. External Ear;
       1. Pinna; 2. Auditory Canal;
       3. Tympanum.
     - 2. Middle Ear;
       1. Eustachian Tubes;
       2. Bones;
         1. Number; 2. Uses;
         3. Articulation.
     - 3. Internal Ear;
       1. Vestibule; 2. Semicircular Canals;
       3. Cochlea; 4. Otoliths, etc.;
       5. Fibers of Corti.
   - 2. Philosophy of Hearing;
   - 3. Definition of Sound;
     1. Physiological Definition;
     2. Physical Definition.
   - 4. Care of the Ear.

SUPPLEMENTARY.

QUESTIONS.

1. Why do sour substances cause the face to pucker?
2. What is thought to be the cause of color-blindness?
3. What is meant by the expression "colors which we cannot see?"
4. Is it probable that some animals see colors which we do not see?
5. Can you answer the last two questions if so modified as to apply to the ear?
6. How do blind people read?
7. Can the sense of touch be deceived?
8. Why are sand, sulphur, and some other mineral substances, tasteless?
9. How fast do light and sound travel?
10. In the animal kingdom, what is meant by "compound eyes?"
11. Can you name some animals that have a large number of eyes?
12. If a violent explosion should occur in space just beyond the limits of our atmosphere, could it be heard upon the earth's surface?
13. What are the uses of the eyebrows and eyelashes?
14. Do all nations have eyes of the same shape?
15. What portions of the brain are supposed to be devoted to the special senses?
16. What ludicrous mistake did Whittier, the poet, make on account of his color-blindness?
17. What is peculiar in the structure of a nerve?
18. Why will a bitter taste produce vomiting?
19. A white object seems larger than a black object. Can you explain this?
20. Can you write a couplet which shall constitute a key for the cranial nerves?
21. Can you explain the philosophy of coughing while one is asleep?
22. How do nerves differ from telegraph wires with regard to transmission of current?

ANSWERS.

1. In the edges of the tongue there is a branch of the same nerve which goes to the face. This nerve is particularly sensitive to sour (acid) substances, and the facial branch acting in sympathy with it, causes distortion.

2. It is believed that difference in color is merely a difference in the wave lengths of the ether vibrations which produce the sensation of sight; and, that the terminal organs are so constructed that certain vibrations will give rise to certain sensations, and also, that only certain parts of the apparatus can be affected by a particular mode of motion. Hence, if some parts of the rods, cones, etc., of the retina are defective, certain colors cannot be distinguished.

3. In the solar spectrum there are evidences of rays of light beyond the limits of the seven (rainbow) colors. These rays cannot be seen, but their presence is readily determined by their physical and chemical effects. These rays would produce the sensation of color if the eye were capable of being affected by them, that is, if it could be affected by this particular mode of motion.

4. It is very probable that the eyes of some animals are so constructed that they can see some of the colors in the solar spectrum which are invisible to the human eye.

5. It is known that sound is that vibration of the atmosphere which is capable of affecting the auditory nerve. Hence, the ear, like the eye, is limited in its compass. There may be certain sounds for which there is no fiber (fibers of Corti) in the human ear, that is, no fiber which can take up this particular mode of motion. Middle C in the piano will vibrate in sympathy with a certain musical note, which may be uttered by the human voice, but it can not be set in motion by a note of any other pitch. The same principle obtains in the tiny "stringed instrument" in the ear. Some animals may hear sounds which, to us, are perfectly inaudible.

6. Printed matter, for the blind, consists of raised letters. Writing is accomplished by puncturing the paper with a pointed instrument. The reader passes his fingers over these letters, and distinguishes them by the sense of touch.

7. The sense of touch may readily be deceived. Cross the first and second fingers and place the tongue between them. You will feel *two* tongues. Touch the back with two objects less than an inch apart. It will feel like *one* object.

8. Any substance which is insoluble in saliva is tasteless. Salt has taste for this reason, while sulphur has none.

9. Light moves 186,000 miles per second. Sound travels 1,090 feet per second when the temperature of the air is at the freezing point, and for every degree of rise in temperature (Fah.) its speed is increased 1.12 feet. At ordinary temperature sound travels about 1,120 feet per second.

10. The eyes of some invertebrate animals consist of cones radiating from a common center. Each cone is really an eye in itself.

11. It is a curious fact that the ant has 50 eyes; the common house fly, 4,000; the butterfly, 17,000; and some beetles, over 25,000.

12. Sound is capable of being propogated only by means of material media. Hence, sound cannot be transmitted to us from the regions of space.

13. The eyebrows keep the perspiration of the forehead from entering the eyes. The eyelashes keep the dust from falling upon the eyes.

14. Yes, the eyes of all nations and of individuals are very nearly the same in shape, and also, in size. The *apparent* shape and size of the eyes of the European and Chinese vary greatly. This difference in appearance depends on the shape and dimensions of the openings of the lids, which are oblique and small among the Oriental people.

15. The area of touch is just above, and back of, the ear; the area of taste and smell is in front of the ear; hearing is above, and in front of the ear; sight is located in the posterior portion of the brain.

16. It is related that, in repairing the damaged wall paper in his library, he matched a green vine with one of bright crimson.

17. A nerve is composed of a bundle of fibers, each of which is a tiny tube. A nerve has no branches, but passes from its origin to the brain. When two or more nerve fibers seem to unite, they are simply packed together like a bundle of threads each remaining perfectly distinct. One set of fibers carries messages to the brain; another set brings messages from the brain.

18. The nerves which taste bitter things are located at the base of the tongue. A branch of this nerve leads to the stomach. Through sympathetic action, this nerve may cause the stomach to contract and produce vomiting.

19. The image formed on the retina by a white object is larger than one formed by a dark object of the same size. It seems that parts of the retina, just beyond the outline of the image, are affected by a bright or white object. This phenomenon is known in Physics as Irradiation.

20. **On old Moriah's peaked tops,**

A Finn and German picked some hops.

The initial letters in this couplet are the initial letters of the cranial nerves in their order, viz: Olfactory, Optic, Motor oculi, Pathetic, Tri-facial, Abducens, Facial, Auditory, Glossopharyngeal, Pneumogastric, Spinal-accessory, and Hypoglossal.

21. Breathing is controlled by the medulla-oblongata. In-as-much as this part of the brain never "sleeps," it seeks at once to relieve any irritation in the breathing apparatus by violent expulsion of the air—coughing. It may be remarked in this connection that while some of the faculties of the mind seem to sleep, there are others which seem never to lose their activity. Since the mind is a mere emanation, i. e., a force, and not a material existence, its perpetual wakefulness is necessary to the continuation of its existence.

22. A nerve is capable of transmitting a current in but one direction, while a telegraph wire will carry currents in both directions. This is due to the fact that the *generator* of the nerve current is at *one end* of the nerve.

LESSON XII.

NARCOTICS.

TOPICAL OUTLINE.

1. **Definitions.**

2. **Kinds.**

   1. Alcohol; 2. Tobacco;
   3. Opium; 4. Ether;
   5. Chloroform; 6. Cocaine; Etc.

3. **Allied Substances.**

   1. Stimulants;
      1. Coffee; 2. Tea; 3. Cocoa.
   2. Depressants.

4. **Origin of Alcohol.**

   1. Decomposition of Sugars;
   2. Processes of Manufacturing;
      1. Fermentation; 2. Distillation.
   3. Varieties of Alcoholic Beverages;
      1. Wine; 2. Beer;
      3. Whiskey; 4. Cider; Etc.

5. **Varieties of Alcohol.**

   1. Methyl; 2. Amyl; 3. Ethyl.

6. **Properties of Alcohol.**

   1. Physiological;
      1. Intoxicating; 2. Antiseptic;
      3. Anæsthetic;
      4. Effect on—
         1. Plants; 2. Animals.
   2. Chemical;
      1. Affinity for Water;
      2. Inflammability;
      3. Volatility.

7. **Composition of Alcohol.**
   - 1. Elements;
     - 1. Carbon; 2. Oxygen; 3. Hydrogen.
   - 2. Proportion of Elements.

8. **Alcoholic Beverages.**
   - 1. Varieties.
     - 1. Distilled Liquors;
       - 1. Whiskey; 2. Brandy; Etc.
     - 2. Fermented Liquors;
       - 1. Wine; 2. Cider; Etc.
     - 3. Malted Liquors;
       - 1. Beer; 2. Ale; Etc.

9. **Identity of Alcohol in Liquors.**

10. **Physiological Effects on—**
    - 1. Circulation; 2. Heart;
    - 3. Membranes; 4. Lungs; 5. Blood;
    - 6. Digestion; 7. Liver; 8. Kidneys;
    - 9. Eyes; 10. Brain.

11. **Alcohol as a Food.**
    - 1. Non-assimilation; 2. Expulsion.

12. **Production of Heat and Strength.**
    - 1. Result of Experiments.

13. **Progressive Appetite.**
    - 1. Law of Heredity; 2. Total Abstinence.

14. **Tobacco.**
    - 1. Preparation;
    - 2. Physiological Effects;
      - 1. Nervous Prostration;
      - 2. Inflames Mucous Membrane;
      - 3. Impedes Growth;
      - 4. Disorders Nervous System.
    - 3. Constituents of Tobacco Smoke;
    - 4. Poisonous Principles of Tobacco.

15. **Preparation, and Physiological Effects of—**
    - 1. Opium; 2. Ether;
    - 3. Chloroform; 4. Cocaine;
    - 5. Hasheesh; Etc.

SUPPLEMENTARY.

QUESTIONS.

1. Why is alcohol used to preserve anatomical specimens?

2. Why does alcohol particularly affect the brain?

3. What is the chemical composition of alcohol?

4. What are the principal kinds of ferments?

5. What two organs of the body are most affected by alcohol?

6. What is yeast?

7. How does alcohol interfere with digestion?

8. How and when was alcohol discovered?

9. What is a narcotic?

10. Beer drinkers appear fleshy and robust; does this indicate good health?

11. How are alcoholic beverages frequently adulterated?

12. What is the origin of the word "intoxicate?"

13. What is the origin of the word "nicotine?"

14. Of what did the Northmen make an intoxicating liquor?

15. Is the manufacture and sale of intoxicating beverages a fraud?

16. If the manufacture and sale of intoxicants is a fraud, why are not persons engaged therein punishable by law?

17. What is the difference between alcohol and vinegar?

18. The greater portion of our internal revenue, which pays the expenses of our government, is derived from the sale of intoxicating liquors; is not this a redeeming feature of the business?

19. What is made from opium?

20. Of what are most patent medicines made?

21. What is the difference between a cigar and a cigarette?

22. How is chloral manufactured?

23. If alcohol is a narcotic, why does it excite those who drink it?

24. What "privileges" were granted by the early temperance pledges?

25. What is an anaesthetic?

26. Can you name any other intoxicating substances besides those mentioned in the outline?

27. Can water quench the thirst caused by tobacco or alcohol?

28. What is the "gold cure?"

29. What is an alkaloid?

30. How is opium obtained?

31. How are chloroform and ether made?

32. What tissue is attacked most severely by alcohol?

33. What classes of persons are most likely to become addicted to the use of alcoholic drinks?

34. How does alcohol check the process of oxidation?

35. What is the most remarkable thing about alcohol?

36. Persons while intoxicated have died very suddenly. Can you explain the cause?

37. What is dipsomania?

ANSWERS.

1. Alcohol is an antiseptic, and will destroy all germs which cause putrefaction.

2. Alcohol has a great affinity for water; and, as about 80 per cent. of the brain is water, it collects in this organ and destroys the delicate tissues.

3. It is composed of two atoms of carbon, six atoms of hydrogen, and one atom of oxygen.

4. Vinous fermentation and acetous fermentation. The former process changes sugar into alcohol and carbonic acid. The latter changes alcohol and other substances to vinegar. Cider will undergo, in succession, both of these fermentations.

5. The liver and the brain. More alcohol goes to the liver than to any other organ. The brain comes next. There is some difference of opinion in this matter however, and many good authorities contend that more alcohol goes to the brain than to any other organ.

6. Yeast is a microscopic plant, a fungus, which, in its growth, decomposes sugar and starch, and produces fermentation.

7. It coagulates the albumen, precipitates the pepsin, increases the secretion of mucus, and stops, to a great extent, the flow of gastric juice.

8. It is believed that an Arab by the name Albucasis, discovered alcohol about 700 years ago. Scientists all over the world were at that time in search of two things: "The Philosopher's Stone," and the "Elixir of Life." The former, they thought, would turn any of the common metals into gold. The latter, would keep those who drank it, young forever. In making experiments with wine, with the hope of discovering the Elixir, Albucasis discovered alcohol. He had dscovered, not the preserver, but the destroyer of life. He had discovered the "Water of Death."

9. A narcotic is a substance that paralyzes, deadens, and otherwise deranges the brain. Alcohol and tobacco are among the most powerful narcotics.

10. No, it does not. The fleshy appearance of beer drinkers is due to *fatty degeneration*. In spite of their robust appearance, they are peculiarly subject to a long train of diseases.

11. They are frequently diluted with water, and the loss of strength made up by such drugs as sugar of lead, copperas, logwood, arsenic, strychnine, and sulphuric acid. Wines are particularly subject to adulteration. Some drinks sold under this name are made from poor whiskey, which has been "toned up" and flavored to have something of the taste of wine.

Statistics show that there is more "port" wine sold in New York each year than is made for the markets of the whole world. The whole business from beginning to end is a gigantic swindle.

12. The word "intoxicate" is from the Latin: *in*, meaning into, and *toxicum*, a poison. Hence, the word means poisoned. The northern European tribes dipped their arrows in a poison which produced an effect upon the person wounded somewhat similar to that produced by the drinking of alcohol.

13. The word "nicotine," is derived from John Nicot, who introduced tobacco into France.

14. The Northmen made an intoxicating liquor called Mead, by fermenting honey and milk. This was one of the earliest of "manufactured" liquors.

15. It is a princple of economics that in the processes of exchange each shall receive an equivalent for that which he gives. In this exchange, the party that receives the intoxicant, receives an article which has in reality no value. The whole business is morally and in reality a fraud.

16. The law does not discriminate in the value of commodities. And as it has never been established by law that intoxicants are valueless and injurious, this traffic cannot be *legally* classed a fraud. The business may be rendered illegitimate by ballot.

17. The chemical composition of vinegar differs as much from alcohol as alcohol does from sugar. By fermentation, alcoholic beverages are made from sugar; by a second fermentation, which will readily take place in such liquors as cider, vinegar is produced. Sugar and vinegar are foods. The former is a positive; the latter, a negative food. Alcohol, on the other hand, cannot be considered a food in any sense.

18. It is not by any means a palliation, but, on the contrary, is one of its deplorable features. The drinking portion of our population is, as a rule, in destitute circumstances, and the enormous tax they pay renders their condition yet more wretched. He who consumes a gallon of whiskey pays ninety cents to the government.

19. Laudanum, morphine, paregoric, and all so-called "painkillers" and "soothing syrups" contain more or less opiun

20. Nearly all patent medicines are made of the extracts of herbs and alcohol. The alcohol is mainly used to prevent fermentation, *i e.*, to keep the extracts from spoiling. The injurious effect of the alcohol is scarcely ever equaled by the medicinal properties of the herbs, especially when taken by one whose hereditary proclivities make him an easy subject for the destroyer—alcohol.

21. The only difference is in their wrappings. The cigarette is wrapped in a kind of paper, called rice paper. On account of the expensiveness of this article, common paper, which has been made to imitate the real article, is used. The smoke of this paper is fearfully injurious to the delicate linings of the throat.

22. If chlorine and alcohol be mixed and exposed to the sun's rays, chemical action will take place and a new substance known as chloral hydrate will be formed.

23. One of the first effects of alcohol is to paralyze the nerves, thus causing the capillaries to lose their contractility; the blood meeting with but little resistance now surges through the body with increased rapidity. Every organ, and especially the brain, is unusually stimulated by the increased supply of blood. The excitement, however, is only temporary and stupor soon follows.

24. In the early temperance pledges, it was permitted to drink wine, beer, and cider on ordinary occasions. The other alcoholic drinks were forbidden except at weddings and funerals, in which cases, the signer was released from all restrictions, and permitted to drink what he chose.

25. It is a substance which has the power of causing temporary paralysis of the nerves, thus destroying all sensibility.

26. Any substance which induces sleep has anaesthetic or intoxicating properties. Two of the most noted are bromide of potassium, and hasheesh, the product of Indian hemp.

27. Tobacco and alcohol by their tendency to inflame the tissues, and their effects upon the nerves, produce an unnatural thirst which water cannot quench. It will, however, *temporarily* relieve it. Nothing but a narcotic will relieve this thirst.

28. Bi-chloride of gold has been found to have the remarkable property of destroying the craving of the appetite for alcohol. It seems, also, to change the *taste*, and one who has been treated with it finds a great difference in the taste of many substances, especially those containing alcohol and acids. It is often called the 'Keeley Cure,' from its discoverer.

29. An alkaloid is a *base* found in some vegetables as a *proximate principle.*

30. Opium is the dried juice of the white poppy, a plant which grows in China and other eastern countries. Morphine is an alkaloid from opium.

31. Chloroform is made by distilling chloride of lime in alcohol and water. Ether is prepared from alcohol by the action of sulphuric acid at a high temperature.

32. On account of its affinity for water, alcohol attacks nervous tissue with greatest severity. It has been known to accumulate in the brain to such an extent that it has been possible to distill it from the brain of a man who had died while intoxicated.

33. There are two general classes. The first are those who through ignorance or indifference or simply because their will power is too weak to resist slight influences form the habit. The second class are those who begin its use for its medicinal properties and find the appetite, which has been aroused, too strong to be put down after its use as a medicine seems no longer necessary.

34. Alcohol affects the blood corpuscles in such a way as to make them incapable of carrying oxygen. In alcoholized blood, the red corpuscles have been deprived of their brilliantly red centers. For this reason the chemical action which takes place in the tissues is not so active.

35. The most striking property of alcohol is, in a Physiological sense, its affinity for water. It is to this property that its terrible ravages are almost entirely due.

36. Alcohol has the power of coagulating albumen. If the blood becomes heavily charged with it, sudden coagulation of all the blood in the body may take place. This would produce sudden death.

37. The intense craving for alcohol or other narcotic substances is called Dipsomania. It is a disease of the nervous system.

LESSON XIII.

THERAPEUTICS.

TOPICAL OUTLINE.

1. **Diseases.**
   - 1. Causes;
     - 1. Ancient Ideas; 2. Germ Theory;
     - 3. Predisposing Influences.
   - 2. Characteristic Derangements;
     - 1. Structural; 2. Functional; 3. Physical.
   - 3. Treatment;
     - 1. Preventive;
       - 1. Hygiene; 2. Sanitation;
       - 3. Disinfectants.
     - 2. Curative;
       - 1. Hygiene; 2. Medicines.
   - 4. Classification;
     - 1. As to Extent—
       - 1. Local; 2. General.
     - 2. As to Distribution,—
       - 1. Epidemic; 2. Endemic; 3. Sporadic
     - 3. As to Dissemination—
       - 1. Contagious; 2. Non-Contagious.
     - 4. As to Duration and Intensity—
       - 1. Chronic; 2. Acute; 3. Sub-Acute.

2. **Materia Medica.**
   - 1. Allopathic System;
     - 1. History; 2. Theory.
   - 2. Homœopathic System;
     - 1. History; 2. Theory.
   - 3. Eclectic System;
     - 1. History; 2. Theory.
   - 4. Medicines;

     1. Systemic; (General Remedies.)
        - 1. Astringents;
          - 1. Vegetable—1. Oak Barks;
            - 2. Roses; 3. Sumach.
          - 2. Mineral—1. Alum; 2. Bismuth.

2 Materia Medica. (Continued.)

4. Medicines;
   - 2. Tonics;
     - 1. Vegetable—1. Wild Cherry Bark; 2. Quassia; 3. Gentian.
     - 2. Mineral—1. Sulphuric Acid; 2. Iron; 3 Lactic Acid.
   - 3. Antispasmodics;
     - 1. Musk; 2. Camphor; 3. Coffee; 4. Tea.
   - 4. Anaesthetics;
     - 1. Chloroform; 2. Ether.

2. Systemic; (Local Remedies.)
   - 1. Emetics;
     - 1. Vegetable—1. Bloodroot; 2. Mustard.
     - 2. Mineral—1. Antimony; 2. Alum.
   - 2. Cathartics;
     - 1. Laxative;
       - 1. Magnesia; 2. Sulphur.
     - 2. Purgative;
       - 1. Senna; 2. Castor Oil.
   - 3. Diuretics;
     - 1. Digitalis; 2. Juniper; 3. Turpentine.
   - 4. Expectorants;
     - 1. Nauseating;
       - 1. Lobelia; 2. Tartar Emetic.
     - 2. Stimulating;
       - 1. Tar; 2. Ammoniac.

3. Non-Systemic;
   - 1. Antacids;
     - 1. Sodium; 2. Lime.
   - 2. Digestants;
     - 1. Pepsin.
   - 3. Anthelmintics;
     - 1. Pinkroot; 2. Wormseed.
   - 4. Absorbents;
     - 1. Charcoal.
   - 5. Disinfectants;
     - 1. Lime; 2. Carbolic Acid; 3. Borax; 4. Iodine.

SUPPLEMENTARY.

QUESTIONS.

1. Who was "The Father of Medicine?"
2. What other men were prominent in the development of the science of medicine?
3. What school of medicine has been founded within the last century?
4. How was the Homoeopathic method of treating diseases discovered?
5. How was vaccination discovered?
6. How is quinine prepared?
7. Can chronic diseases be cured?
8. Is consumption curable?
9. What are the uses of the following instruments: Stethoscope, speculum, and ophthalmoscope?
10. What is Therapeutics?

ANSWERS.

1. Hippocrates, a Grecian physician, who was born 460 B. C., is so-called. He was the first to reduce the practice of medicine to a science.

2. Pythagoras, who lived about 100 years before the time of Hippocrates, was the first to practice this art. Serapion was the great physician of Alexandria, and founded a new system of medicine which, in distinction from the Dogmatic system of Hippocrates, was called the Empiric system. The next great physician, and also medical writer, was Galen, a Roman doctor, who lived in the second century, A. D., and whose precepts were followed by the medical profession for over 1,000 years.

3. The most remarkable departure from the regular system of medicine in the treatment of disease was made at the begininng of this century by a German physician named Hahnemann. The name Homoeopathy, likeness of condition, was adopted as expressive of the principle upon which it is founded, viz.: *like cures like.*

4. In 1790, while Hahnemann was translating an English medical book into the German, he became dissatisfied with the explanations given of the effects of quinine. He took several large doses to observe its effects, and soon experienced, as a result the ordinary symptoms of ague. The thought occurred to him that the same thing which will cause, will cure, or in other words, *like cures like.*

5. Edward Jenner, an English physician, had made some special inquiries into the nature and treatment of the cow-pox. He noticed, during a certain plague of the small-pox that the milk-maids were nearly exempt from the epidemic. Further investigation showed that none of those who had had the *cow-pox* were attacked by *small-pox*. He reasoned that, if he could induce a mild varioloid disease by inoculation, it would prevent the more serious small-pox. Experiment proved the truth of these deductions.

6. Quinine is an alkaloid obtained from the bark of the cinchona tree which grows in Peru—hence the name, Peruvian bark. The bark is boiled in water containing one per cent. of oil of vitriol. The solution is then precipitated by means of carbonate of sodium.

7. But very few, if any, of the chronic diseases are curable. Such diseases as catarrh and other local inflammations may be alleviated to such an extent as not to cause any suffering or inconvenience, even to the patient.

8. The medical world has long, and diligently, searched for a specific for this dread disease, but with little success. Yet, it seems quite certain that consumption in its different forms has been cured. Recently a German physician named Koch, has prepared a lymph which is claimed to have the power of arresting the disease. Cod liver oil retards the disease very remarkably.

9. The stethoscope is an instrument which, when placed on the chest, enables the operator to hear sounds in the lungs and heart. The speculum is an instrument for illuminating, for examination, the interior of the body. The ophthalmoscope is an instrument for examining the interior of the eye by reflecting light into it.

10. Therapeutics is the science which treats of diseases and their treatment.

EXPERIMENTS.

The teacher should exercise much care in performing demonstrations before a class. Unless he has had practice in a chemical laboratory, an experiment will sometimes fail because his skill is not sufficient to perform the mechanical part. It is a good plan that one perform an experiment before the class assembles in order that its success may be assured. In these pages we have selected some of the most interesting and instructive experiments in Physiology, and presented them in their simplest forms. In dissections, the parts should be scrupulously cleaned in order that very sensitive pupils may not be unpleasantly affected. Perform an experiment with all the skill you can command.

The propriety of making experiments with alcohol in the school room has been questioned. May "touching and handling" lead to "tasting?" This is a serious question. If the teacher has any misgivings on this point, his line of duty is clear.

I. To Tie a Bone in a Knot.

Procure the rib of a young sheep, fresh from the meat market. Place this bone in a solution made of four parts of water and one part of nitric acid, and allow it to remain until it can be penetrated by a sharp instrument, as a pin. This will require from six to twelve hours. Then put the bone into clear water and allow it to remain for several hours so that the nitric acid may be removed. Then the bone may be handled, and its flexibility easily demonstrated. If it is long enough it may be tied in a knot.

II. To Prepare a Skull.

The skull of a rabbit is desirable for this purpose. After removing the skin from the head, boil the head gently for a considerable length of time so that the flesh will come off very easily. With a fine, sharp saw cut the skull through the base so that it may be lifted off, and the brain removed. Remove all the vertebrae except the axis and atlas, which should be preserved to illustrate their wonderful mechanism. Clean all the parts very thoroughly. You can now examine the shape of the bones, their positions, articulations, and other interesting features. Especially examine the cavities of the eye and ear, and the inner surface of the skull. Preserve this specimen for future use.

III. To Demonstrate Circulation.

Procure a frog of medium size; wrap it in a piece of cheese cloth, allowing one hind leg to protrude. Then fasten upon a thin board, in which a hole has been cut. With two pieces of fine thread, looped on two consecutive toes, bring the web over the hole in the board. These threads may be fastened by means of pins, or niches made in the board. Adjust the focus, and the circulation in the web will come into view. The experiment should be performed in a warm room, and the web, as well as the cloth, should be kept moist. This is one of the most wonderful of microscopic revelations. Words cannot describe what the eye will behold. Notice the elliptical form of the corpuscles—a characteristic of the blood of all the frog family.

IV. To Demonstrate the Presence of Carbon Dioxide in Expired Air.

Fill a tumbler half full of lime water. Notice the transparency of the liquid. Now blow through a glass tube, one end of which is placed in the liquid. It will be necessary to continue this for some little time, when it will be

observed that the water is assuming a milky appearance. The carbon dioxide in the expired air has united with the lime in the water, forming what is known as carbonate of lime.

V. To Examine Blood Corpuscles.

Tie a cord tightly around the base of a finger. This will shut off the venous circulation, and the finger will become gorged with blood. Prick it slightly with a pin or needle, back of the finger nail, and let a small drop of blood exude. Take two pieces of glass well cleaned, and put the drop between them. Press the pieces of glass together and put under the microscope. When the focus has been adjusted, the red corpuscles will come into view. They will be found gathered in rows like coin. Strange as it may seem, the corpuscles appear to have the power of moving about. They seem to be endowed with the life principle. The white corpuscles can be detected only by a microscope of high power.

VI. To Illustrate Digestion.

To make artificial gastric juice, put ten grains of pepsin (pure) and a half dram of hydro-chloric acid into a pint of water. Take one-third of the white of an egg which has been boiled about fifteen minutes, and grate it into the gastric juice. Warm the mixture to a temperature of 102 degrees Fah.,—the normal temperature of the stomach,—and shake often, in imitation of the peristaltic movement, until the mixture begins to have a transparent appearance. It is necessary to keep the temperature at the proper point for several hours. If the pepsin and hydro-chloric acid were good, all traces of the egg will have disappeared—it has been digested.

VII. To Illustrate Nerve-Current.

Procure the hind legs of a frog. Neatly remove the skin. Take a piece of zinc and a piece of copper, each about three-fourths inch wide and three inches long, and

place two ends between the thumb and finger with the other ends parted (like open scissors). Find the crural nerves, which are located near the bones and may be distinguished by their white and glistening color, and touch these with one of the metal strips while the other comes in contact with any part of the muscular tissue of the legs. A current of electricity will be generated which will pass through the nerves, and, to the astonishment of the beholders, will cause the legs to "jump." This experiment must not be performed later than an hour after the frog has been killed.

NOTE. This experiment should not be performed before a class of young pupils. The science involved is too deep for their penetration; and moreover, the spasmodic jerking of the legs will arouse their sympathies, and impress them with the idea of cruelty. To an *advanced* class it is a marvelous revelation. In connection with this experiment, rehearse Galvani's discovery of current electricity.

VIII. To Illustrate Reflex Action.

Let a pupil sit on a chair with one leg crossed over the other. With the tips of thumb and fingers have him strike the ligament in the leg just below the knee cap. Notice that the foot is jerked up, but not instantly. Notice also that the pupil is unable, to a great extent, to control this action of the muscles. This is reflex action. The brain has nothing to do with it. The sensory nerve, stimulated by the blow, sends a message to the nearest nerve center, from which the motory nerve carries a counter message stimulating the muscles which cause them to contract. This also will illustrate the involuntary action of a muscle which is, by nature, voluntary.

IX. Dissection of the Heart.

The heart of a sheep is most convenient for our purpose. Leave your order for a heart at a meat market with instructions that the enveloping membrane—pericardium—shall be left intact, and that the veins and arteries shall not be cut very close to the heart. With scissors cut away the

pericardium. Notice its inner and outer lining. Wash the heart very carefully. Commence at the ends of the blood vessels and cut off small sections until you have reached the auricles, noticing carefully the character and number of openings. Now, with a sharp knife, cut off the tip of the heart. You will be surprised to find how far the ventricles extend. Cut off one thin slice after another until you have reached the middle of the heart in cross-section, noticing carefully, as you proceed, the form of the ventricles in both open and closed positions. With a glass tube, or goose quill, blow into the arteries and notice that the valves come into position and entirely close the opening. Then cut the heart in longitudinal section, through the ventricles, and the inner valves, together with the cords and pillars which act as stays to the valves, will come into view.

X. Dissection of the Eye.

The eye of a sheep, or of an ox, will serve our purpose best. Wash it very clean and trim off the fat around the optic nerve. Take a firm hold of the optic nerve; bring the integument to a tension; and, with a knife *as sharp as a razor*, cut through the integuments in a circle, which might be considered the equator,—being very careful not to cut into the vitreous humor. Then lift off the upper hemisphere, leaving the vitreous humor intact. The retina, the yellow spot, and the blind spot; and also the three coats in cross-section may be examined from the part held in the left hand. Next, cut the sac which holds the crystalline lens and at the same time sever the cornea from the sclerotic coat. The fluid which escapes is the aqueous humor. The cornea and crystalline lens should be placed on a piece of paper and inspected by the class. The iris and pupil should be examined before the dissection begins. Remember, that in this experiment, you need a good, sharp knife.

XI. To Perform Distillation.

Into a teapot which has a long spout, put a quantity of hard cider. The surface of the liquid must be below the opening into the spout. See that the lid fits well. Take a piece of rubber tubing about two feet long and draw one end of it over the spout. Insert the other end in a glass jar. Heat the cider by means of a spirit lamp and place the glass jar in cold water, or better still, on a block of ice. The vapor, driven through the tube, will be condensed in the jar. The presence of alcohol in the jar may be tested by applying a lighted match to its contents. If it is not too much diluted with water, it will burn. If it does not burn, it will be necessary to redistill it. The alcohol has not been *manufactured* by this process but simply *extracted* from the cider.

XII. To Demonstrate the Effect of Alcohol on Albumen.

Put the white of an egg into a tumbler and pour upon it about an ounce of alcohol. Stir it with a glass tube, or end of a penholder, and carefully notice the transformation. In a short time, it will appear to have been "cooked." It has been coagulated by the action of the alcohol. In the human stomach, alcohol works the same change on albuminous foods, and seriously interferes with the action of the pepsin.

XIII. To Demonstrate the Effect of Alcohol on Plant and Animal Life.

Put a drop of alcohol on the web of a frog's foot. Almost immediately there will be signs of congestion. If we could, at this instant, examine it with a microscope, we would see that the blood vessels are greatly dilated, and that the circulation has been wonderfully accelerated. Very soon, however, it will stop entirely. It now shrivels up and will slough away. Place a drop of alcohol on a leaf. Notice that the tissues seem to undergo a change. It, too, will shrivel and die from the poisonous effect of the same agent.

XIV. To Demonstrate the Affinity of Alcohol for Water.

Take a bottle and fill it three-fourths full of water. Then pour in enough alcohol to fill it. Notice carefully to what height the surface of the mixture rises in the neck of the bottle. Shake the bottle vigorously, being careful at the same time that none of the contents are spilled, and again observe the height to which the liquid rises. It will not rise so high. Some of it seems to have disappeared. The alcohol has combined with a part of the water, *i. e.*, has chemically devoured it.